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THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

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ADAPTING USED HIGHWAY TRAILERS FOR FARM USE[1]

By W. H. FRIDAY and J. S. BOYD
DEPARTMENT OF AGRICULTURAL ENGINEERING

MANY HIGHWAY TRAILERS become obsolete for road service each year due to changing highway laws, model changes, and general depreciation. These units accumulate at trucking centers because the salvage value is so low that salvage companies are not interested in them. Many of these trailers are still mobile and contain enclosed storage space.

It was thought that these trailers could be used as farm structures. Van trailers are approximately 7 feet 6 inches wide, 7 feet 6 inches high and vary in length from 22 to 34 feet. Flat bed trailers have essentially the same widths and lengths. Being mobile, the trailers could be moved to a site and converted quickly to some type of useful farm structure. To determine their application and value to agriculture, a cooperative study was instituted. Four units were converted and placed into operation on the campus.

The objectives of the project were to determine (1) practical methods of lowering a trailer from its undercarriage onto a suitable foundation, (2) the practicability of modifying used van trailer units to grain storages, (3) the possibility of using flat bed units for farm bridges, and (4) the feasibility of using van trailers for general farm storage.

CONVERTING THE TRAILERS

In most cases, some modification would have to be made to adapt these units to farm uses. In this investigation, all changes were made with inexperienced help and with readily available building materials.

Three methods of lowering a trailer onto a foundation were tried

[1]Acknowledgement is made to Trailmobile Inc. for financial assistance and to the Farm Crops Department and College Farms for their cooperation.

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during the installation of these units. One method was to support the body on four jacks while the undercarriage was removed. Then it was lowered by releasing all of the jacks simultaneously.

The second method was to support one end of the trailer on two columns of blocks while the undercarriage was removed. After the undercarriage was clear of the body, a single column of blocks replaced the two supporting columns. This single column was then collapsed allowing the trailer body to fall freely to the foundation.

The third method was a modification of the second. After the undercarriage was removed from the trailer, an inclined beam was inserted under the trailer and supported on the platform of a truck. (Fig. 1) The truck drove off slowly, lowering the trailer onto the foundation.

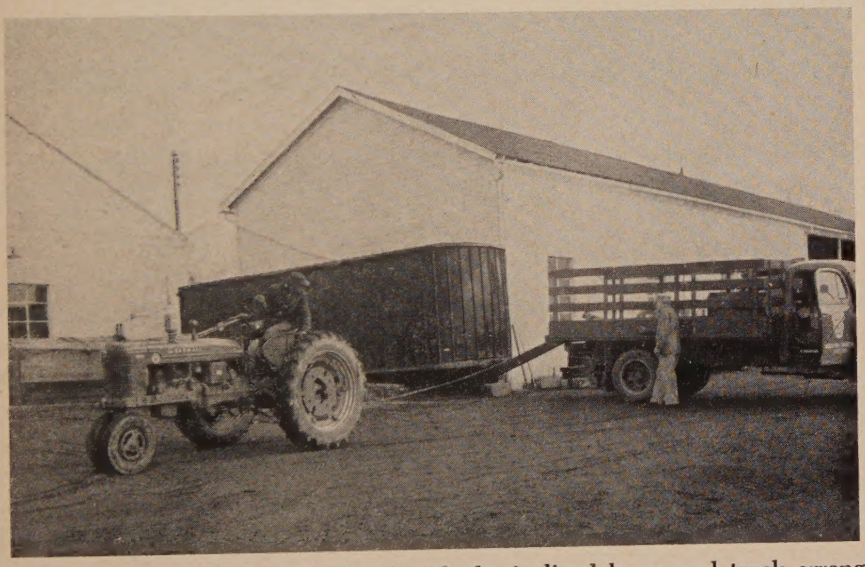

Fig. 1. A trailer being lowered with the inclined beam and truck arrangement. Small adjustments necessary for aligning the trailer with the foundation wall can be made with a tractor as shown.

Two types of foundations were used for the grain storage trailers. The first was a low foundation, two concrete blocks high. (Fig. 2) A level trench was dug for the foundation walls. The blocks were placed under the trailer in the level trench but were not laid in mortar. For permanent installations, blocks laid in mortar would be desirable.

The second method of support was by a series of columns, five blocks high, spaced under the walls at the ends and at the third points of the trailer. (Fig. 2) The trailer was mounted at this height so that

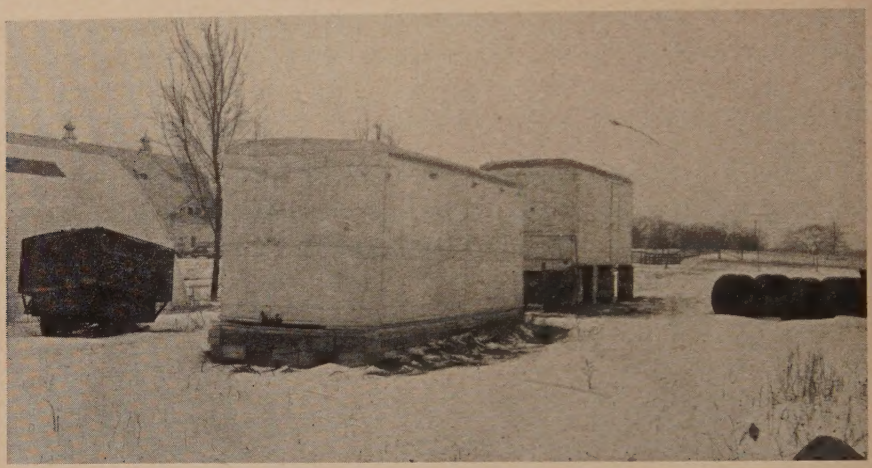

Fig. 2. Two trailers used as granaries. The top row of blocks on the foundation wall are laid open end exposed to provide air circulation under the trailer in the foreground. Eight columns of blocks support the rear trailer at a height of 4 feet.

the undercarriage was left intact, to determine if the unit could be moved when fully loaded. A hole cut in the floor provided for easy unloading. Both of these foundations had sufficient bearing area on sandy loam soil.

The rear doors of these units did not fit tightly enough to hold grain and repel water. A simple wood frame wall inside the door covered this opening, and asphalt roofing paper was applied to make the opening waterproof. Two roof hatches were built to facilitate filling. Six 12 square inch air vents were constructed to ventilate the space between the grain and the roof.

Few changes were required to convert a flat bed trailer into a farm bridge. The undercarriage was cut loose and the bed pulled into position with a farm tractor. Posts were used as abutments for the bridge, and a plank was placed behind the posts to hold back the earth in case of high water. (Fig. 3). If a bridge wider than 8 feet is required, two trailers can be placed side by side.

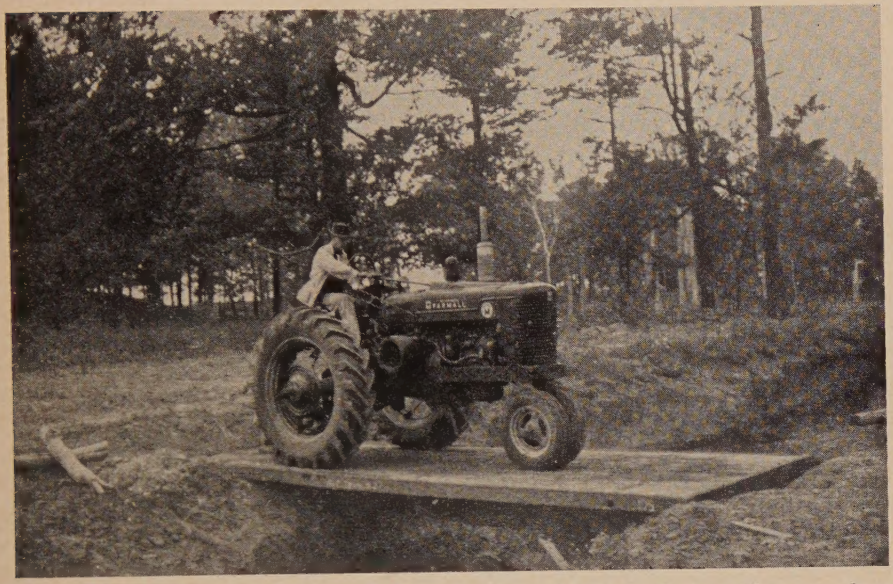

Fig. 3. A flat bed trailer used as a farm bridge. It is wide enough to permit passage of a large farm tractor.

A van trailer lowered onto a foundation near the farm workshop was immediately ready for general farm storage. Shelves were added to provide efficient handling of the stored materials.

DISCUSSION

With a special dolly that converts semi-trailers into four wheelers, the empty trailers were moved satisfactorily on level ground with a two plow tractor. Whether the trailers could be relocated with farm power when fully loaded was not determined.

Lowering trailers onto foundations required a considerable number of man-hours of labor. The inclined beam and truck arrangement was the most satisfactory method for controlling the lowering process. This method required 27 man-hours to set the trailer on the foundation. This included building the foundation, cutting out the undercarriage and lowering the trailer. A faster way, requiring only 14 man-hours, allowed the trailer body to fall onto a timber or log. This did not control the lowering process, although no detrimental effects were noted during the trials. The procedure of lowering the trailer with four jacks required 52 man-hours and was potentially more dangerous than the other methods.

An estimated 60 dollars worth of building materials were used to repair and convert each trailer into a granary. However, if some of the materials used were native, this expense could be reduced. Slightly more than 100 man-hours of inexperienced labor was used to convert the first trailers; half of this time was needed to lower the trailer by jacks onto the foundation. Succeeding conversions by the inclined beam and free fall procedures reduced the lowering time as much as 50 to 70 percent.

No difficulty was experienced in filling these trailer storages with an average sized farm elevator. The roof hatches as constructed made filling easy. They also made it possible to increase the storage capacity to approximately 800 bushels of wheat in a 22-foot van trailer.

During the summer of 1954, wheat was placed in one van unit and oats in another. Temperature and moisture content measurements of the grain showed that the trailers were providing suitable storage conditions. This converted trailer was approved for storage of wheat placed under government loan.

The flat bed trailer was quickly and easily installed as a farm bridge to permit passage of farm vehicles. (Fig. 3) The only work necessary to convert the trailer was to remove the undercarriage. This required about 6 man-hours. In addition, 40 man-hours were required to dig the holes, set six 4-inch fence posts and drag the trailer onto the foundation. The trailer bed, when mounted on a post abutment, had sufficient strength to carry most farm loads.

Perhaps the most direct use of a trailer as a farm structure is for general farm storage. Twenty-seven man-hours were required to place a van near the farm shop where it provided covered storage for many small tools and farm supplies. Shelves and racks would have to be built to suit the needs of the particular articles to be stored. Due to the limited width and height it might be inconvenient to store regular farm tractors and machinery. However, it would be very satisfactory for small farm tractors and garden tractors.

RESULTS OF 1954 CEREAL SEED-TREATMENT TRIALS IN MICHIGAN[1]

By R. L. KIESLING[2] and J. E. GRAFIUS[3]

EVERY YEAR cereal smuts reduce both yield and quality of grain in Michigan. These reductions vary from a fraction of 1 percent to almost total loss. Recent reports of losses caused by dwarf bunt (*Tilletia brevifaciens* G. W. Fischer) in Ontario, Canada, made by Conners (1954) and Conners and Skolko (1953) and in New York by Tyler (1945) emphasize the importance of seed-treatments in winter wheat.

Seed-treatment trials are made annually at East Lansing to test the ability of seed-treatment compounds to control bunt of wheat and smuts of oats under Michigan conditions and to compare the older, standard materials with the newer chemicals.

METHODS

Naturally infested white winter wheat from a Michigan farm was used in the bunt control trials. This seed contained more than 10 smut balls per 100 kernels, which is a heavy spore load. The fungus was indentified as *Tilletia foetida* (Wallr.) Liro (Fischer, 1953). Each of the chemicals was applied to 75 grams of uncleaned, infested seed. The bunt nursery was planted as late as possible in the fall to insure maximum infection, but early enough to produce a good stand.

Ajax oats were inoculated by the spore suspension vacuum method (Tapke and Beaver, 1942) with loose and covered smuts of oats (*Ustilago avenae* (Pers.) Rostr. and *Ustilago kolleri* Wille) collected in Michigan. After testing the spores for germination, they were added to distilled water in a Waring blendor and mixed until a black suspension was obtained.

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[1]Contribution 55-5 from the Department of Botany and Plant Pathology, Michigan State College.
[2]Department of Botany and Plant Pathology.
[3]Department of Farm Crops.

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The oats were dried slowly for several days after they were removed from the spore suspension. The chemicals were applied to 18 gram samples of dried inoculated grain and allowed to stand several days before planting. The fungicides tested are listed in Table I. Several materials were obtained after the winter wheat was sown in the fall of 1953 and were not included in the tests.

RESULTS

Seventy-five percent infection was obtained for the untreated wheat check. Inoculation of Ajax oats was not quite so successful, because this variety is moderately resistant to covered smut and slightly more susceptible to loose smut (Welsh, *et al.*, 1953). The hull of the oat kernel also protects the embryo from contact with the smut spores. The hulls, however, also protect some smut spores lodged beneath them from the non-volatile chemicals.

The high percentage of infection in the winter wheat is caused by the heavy spore load and the extreme susceptibility of the winter

TABLE 1—Results of the 1954 cereal seed treatments for the control of bunt of wheat and smuts of oats

Material used	Form applied	Rate oz./bu.	Average percent smutted heads	
			Winter wheat*	Oats†
None	....	....	75.0	3.0
Ethyl I	Dust	1.0	——	5.0
Ethyl I	Dust	2.0	——	4.0
N.I. Ceresan	Dust	0.5	15.0	0.5
Orthocide 75	Dust	0.75	66.0	2.0
Parson's S.S.	Dust	0.5	70.0	2.0
Ceresan M	Slurry	0.5	1.0	2.0
Agrox	Slurry	0.5	0.0	1.0
Orthocide 75	Slurry	0.75	6.0	1.0
Ethyl II	Slurry	2.0	——	2.0
Mergamma	Slurry	1.5	0.0	0.5
Gy-trete	Liquid	0.5	0.0	1.0
Panogen	Liquid	0.75	0.8	0.0
Vancide 51	Liquid	4.0	0.0	1.0
Merculine	Liquid	0.5	0.0	0.0
Mercusol	Liquid	0.5	0.0	2.0
DuPont 364	Liquid	0.75	——	0.0
DuPont 264	Liquid	0.75	——	0.0

*Average of four replicates.
†Average of three replicates.

wheat variety to the bunt fungus. The results of the trials on winter wheat and spring oats are listed in Table I. The dusts gave relatively poor control of bunt in these trials because of the heavy spore load. The wheat was not cleaned, and the results indicate the importance of the cleaning operation before treating.

However, N. I. Ceresan gave significantly better control of bunt than either Orthocide 75 or Parson's Seed Saver. This agrees with the work reported by Leukel (1951, 1952, 1953, 1954). Slurry and liquid type treatments gave much better control of bunt than the dusts. This was the result of better coverage of the kernels by the slurries and liquids which gave better protection even in the presence of a heavy spore load.

In the smut of oats trials N. I. Ceresan dust and Mergamma slurry gave the best control in their respective groups. However, the liquid compounds were generally better in the control of smut of oats than most of the dust and slurry materials.

CONCLUSIONS

These data indicate that there are several compounds which may be used effectively to treat small grain for smut control. These include N. I. Ceresan applied as dust; Cersan M, Agrox and Mergamma applied as slurries; and Gy-trete, Panogen, Vancide 51 and Merculine applied as liquids. The actual field performance of the better compounds in commercial plantings will also depend upon the type of grain treated, how clean the seed is, and how well the seed-treatment materials are applied.

Liquid seed-treatment fungicides offer certain advantages in the treating operation. There is no dust from the chemical during the treating process which reduces the danger to the operator and the grower, and the dye found in some liquids colors the grain and reduces the chance of mixing treated with untreated grain.

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SUNHAVEN AND RICHHAVEN --- NEW PEACH VARIETIES

By Stanley Johnston

Department of Horticulture

The Michigan Agricultural Experiment Station announces the introduction of two new peach varieties, Sunhaven and Richhaven.

These new varieties originated in the peach breeding project carried on at the South Haven Experiment Station where a search has been underway for 30 years for better varieties maturing in succession throughout the peach producing season.

The success of the Redhaven variety, introduced in 1940, resulted in many requests for a variety of this type maturing earlier. Sunhaven is being introduced to meet this need. It matures very early, ripening 10 days before Redhaven and 40 days earlier than Elberta. It is much like Redhaven in color and many other characteristics, but is somewhat clingy until fully ripe, when it is a freestone.

There is also a need for a suitable variety maturing in Halehaven season having brighter color than Halehaven and with somewhat firmer, non-browning flesh. Richhaven is larger than Halehaven, brighter in color, firmer, and has rated highly in commercial canning tests. The stone is completely free and the flesh resists browning.

Detailed descriptions of these two new varieties are as follows:

SUNHAVEN

Sunhaven originated from the cross: Redhaven x SH 50 (J. H. Hale x Halehaven) made at South Haven in 1944. Tested before naming as selection SH 232.

The season of maturity is 10 days earlier than Redhaven and 40 days before Elberta.

Trees of Sunhaven are large, vigorous and productive. No permanent injury resulted to trees of this variety following—19°F.

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Fig. 1. The Sunhaven peach (left) is medium-large, nearly round and uniform in shape. Skin color is bright red with enough golden ground color for attractive contrast. Fuzz is almost unnoticeable. The Richhaven (right) is a large peach, bright golden in ground color, overlaid with a large, bright red blush on the area exposed to the sun, with stripes of red and gold on the opposite side.

on November 25, 1950, although fruit buds of all varieties were killed. Sunhaven has been consistently productive, even following unfavorable blossoming weather in the springs of 1949 and 1954.

Fruits of Sunhaven are medium-large in size, nearly round, and uniform in shape. Skin color is much like Redhaven, largely bright red with enough bright golden ground color for attractive contrast. Pubescence, or fuzz, is so short and soft it is almost unnoticeable. The fruits keep and handle unusually well for such an early maturing variety. Flesh is clear yellow, fine-textured, firm, of good flavor and very resistant to browning. Sunhaven is a freestone when fully ripe but otherwise a partial cling. So far, peach breeders have had to sacrifice some freeness of the stone where extra earliness is desired.

Sunhaven is not recommended as a canning peach because of clinginess while the fruits are firm. Sunhaven's principal value should be as a very early maturing variety of medium to large size, bright color and excellent flavor for the fresh fruit market.

RICHHAVEN

Richhaven originated from the cross: Redhaven x SH 50 (J. H. Hale x Halehaven) made at South Haven in 1944. Tested before naming as selection SH 297.

The season of maturity of Richhaven is about with Halehaven or 14 days before Elberta. Because of its brighter color, it might be picked two or three days before Halehaven.

Trees of Richhaven are large, vigorous and productive. They withstood -19 F. on November 25, 1950 without permanent injury, although fruit buds of all varieties were killed. Richhaven has had an excellent production record.

Fruits are large, nearly round, and uniform in size and shape. The ground color is bright golden, overlaid with a large, bright red blush on the area exposed to the sun, with stripes of red and gold on the opposite side. Very attractive in appearance. Pubescence, or fuzz, is so short and soft as to be nearly unnoticeable. An unusually thick, tough skin adds to the handling and shipping ability of the fruit. Flesh is clear yellow with a moderate amount of red near the pit. It is medium in texture and resistant to browning. The stone is entirely free, even when the fruit is firm ripe.

Richhaven has made a good record in commercial canning trials.

SOURCES OF NURSERY STOCK

Trees will be available in small numbers from many nurseries in the spring of 1956, and in larger quantities thereafter. The Michigan Agricultural Experiment Station does not have trees for sale.

CONTROL OF STRAWBERRY LEAF BLIGHT BY FUNGICIDES[1]

(REPORT OF PROGRESS)

By ROBERT H. FULTON and DONALD CATION
DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

WITHIN THE PAST FEW YEARS, leaf blight has assumed considerable importance. Certain varieties predominantly grown such as Senator Dunlap, Robinson and Red Crop are extremely susceptible. Also, the causal fungus of leaf blight *Dendrophoma obscurans* was recently found associated with stem-end fruit rot (Alexopoulos and Cation, 1948).

It would be expected that fungicides specific for *Dendrophoma obscurans* could be incorporated into programs for control of both leaf blight and fruit rot. For the past several years, exploratory spray tests have been conducted on the susceptible variety Robinson. The control of stem-end fruit rot has been inconclusive, but leaf blight control was attained and a report of that phase of our results seems warranted.

Historical Survey:

In the summer of 1920, Anderson reported the results of his investigations on leaf blight. By actual inoculations he showed that *Dendrophoma obscurans* was the causal organism. No field experiments on control measures were included in his report. The disease was not thought important enough to warrant a control program at that time. This conclusion was supported by Demaree (1942) who maintained that the damage done by leaf blight was not sufficient to practice control measures.

Alexopoulos and Cation (1948) described a new disease called stem-end rot of strawberries. The severity of the disease was shown in their experimental plots where 50 percent of all fruit checked was

[1]Contribution number 55-2 Department of Botany and Plant Pathology.

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infected. They first attributed the fruit rot to the leaf blight fungus, *Dendrophoma obscurans*. During their study, perithecia were noted which were believed to be a part of the perfect stage of *Dendrophoma*. Further work (Alexopoulos and Cation, 1952) led them to consider this ascogenous fungus as a separate organism, *Gnomonia fragariae*. The *Dendrophoma-Gnomonia* complex is still unsolved but both are associated with the stem-end rot disease.

Leaf blight has been reported from Canada by Fall (1951) and Bolton (1954). Fall's observations indicated that Senator Dunlap was extremely susceptible. Bolton's strawberry surveys in Ontario and Quebec showed the *Dendrophoma-Gnomonia* complex to be widely scattered. Not only was this complex responsible for strawberry fruit rot but *Gnomonia fragariae* also caused necrosis of the base of petioles. He contended that *Gnomonia fragariae*, under optimum environmental conditions, could cause severe damage to strawberry unless spray practices were undertaken.

Cation (1948-50), experimenting with ground sprays for the eradication of apple scab inoculum, found that a dormant application of Elgetol[2] (sodium salt of dinitro ortho cresolate) controlled strawberry leaf spot caused by *Mycosphaerella fragariae*. Later this investigator observed that the drip from phenyl mercury acetate sprays applied in the prepink stage to apple trees killed the ascospores of *Venturia inequalis* within the perithecia in the old leaves on the ground. This was evident as a plasmolysis of the spores. These observations prompted a study of eradicant sprays for the control of strawberry diseases, since there were perithecia of *Gnomonia fragariae* present in late summer on strawberries in the leaf blight-fruit rot complex.

Experimental Results:

When strawberry beds are rejuvenated in July, many of the old diseased leaves are destroyed by burning or are buried beneath the soil surface with tillage implements. The reduced leaf surface and plant debris present in the strawberry planting at the time of bed rejuvenation, together with indication of ascosporic inoculum present, strongly suggested trials with eradicant sprays at that time.

Tag 331[3], a 10 percent phenyl mercury acetate, was selected as a representative of the organic mercurials in commercial use. On July

[2]A proprietary dinitro product of the California Spray-Chemical Co.
[3]A proprietary mercury product of the California Spray-Chemical Co.

Fig. 1. Young Robinson strawberry leaf with mottled black pattern indicating foliage injury caused by mercury spray.

11, leaf blight affected plots were sprayed at a dosage of one pint in 100 gallons. Three days later foliage injury appeared in the form of a mottled black pattern on young leaves (Fig. 1). The damage to old leaves begins as a yellowing of the margins and main veins (Fig. 2). Within 10 days, these older leaves were yellowed and dead, while the young leaves recovered and resumed normal growth. There was no apparent injury to the crown of the treated plants. Isolations from the old lesions, made 12 days after spraying, showed that *Dendrophoma* had been killed.

The results of this test were apparent in September when the sprayed plots were remarkably green and free from leaf blight. The adjacent unsprayed plots had a brown appearance from the large amount of leaf blight present. These preliminary trials indicated that the organic mercurials were of value in eradicating the leaf blight fungus.

In 1951, experiments were designed to test the effectiveness of a single eradicant application versus a series of protective sprays. The individual plots were composed of six adjacent matted rows 100 feet in

length. The eradicative program consisted of a single spring application when the first new leaves were just emerging from the crown, using Tag 331 at a dosage of ½ pint in 100 gallons, applied at the rate of 150 gallons per acre. The protective program consisted of three applications: 1) first new leaves emerging, 2) pre-bloom, 3) fruit one-third grown. The fungicides used were Ferbam (ferric dimethyl

TABLE 1—Comparison of results obtained between eradicant and protective fungicidal sprays

Materials	Dosage per 100 gallons	Average number of lesions	Degree of control
Tag 331	½ pint	15.5	97.9
Ferbam	1½ pounds	121.5	83.2
Captan	2 pounds	135.8	81.6
Fixed copper & hydrated lime	2½ lbs. & 4 lbs.	192.5	73.9
Check	none	737.0	0

Fig. 2. Mercury spray causes yellowing of main veins and margins as shown on this old Robinson strawberry leaf.

TABLE 2—Comparison of eradicant fungicides and concentrations for the control of strawberry leaf blight

Materials	Dosage per 100 gallons	Percent of leaflet infection*			
		Healthy	Mild	Moderate	Severe†
Tag 331.....	¼ pint	51.1	38.8	7.2	2.7
Tag 331.....	½ pint	73.8	23.8	2.2	0.0
Tag 331.....	1 pint	82.2	15.0	2.2	0.5
Elgetol.....	½ gallon	30.0	44.4	12.7	12.7
Elgetol.....	1 gallon	28.8	37.7	18.3	15.0
Check.....	none	15.0	25.0	22.2	37.7

*Percentage on a basis of 180 leaflets.
†Healthy -no lesions, Mild -1-5 lesions, Moderate—6-10 lesions, Severe—more than 10 lesions.

dithiocarbamate), Captan (N-trichloromethylthio tetrahydrophthalimide) and a basic copper sulfate containing 53 percent metallic copper.

Counts were made after harvest in the following manner. All the leaflets of four randomized 4 foot sections of matted row in each plot were checked for blight infection. The average number of lesions and degree of control for each treatment is presented in Table 1.

As indicated in Table 1, all materials tested showed significant control of the leaf blight disease. In the protective schedule, Ferbam and Captan gave comparative control and both appear superior to the fixed copper in leaf blight control. However, a single organic mercurial eradicant spray appeared considerably more effective than three applications of protective fungicides.

From the foregoing results, it is quite evident that leaf blight control is feasible using an eradicant program. In 1952, concentrations for economic control and the effectiveness of another eradicant material, Elgetol, were evaluated as post harvest treatments. Three concentrations of Tag 331 were compared with two concentrations of Elgetol.

The plots used for these studies were 4 feet in length and replicated three times. The data was obtained in September by grading 20 compound leaves picked at random from each plot. The results are given in Table 2.

Tag 331 at all concentrations tested showed better control than Elgetol as a post harvest treatment. When correlated with healthy and mild infection percentages, the ½ pint strength appears to be the most feasible for commercial use.

In many plantings, leaf blight was so severe it was questionable if one application of an organic mercurial would give sufficient control. Thus, in 1953 plots were sprayed in the following manner using ½ pint concentrations of Tag 331—fall only, fall plus spring and a spring application only. The data were obtained on percentage of leaflet infection (Table 3).

Table 3 shows that one application in the fall gives moderate control of leaf blight. Two applications, one in the fall and the next in the spring, gave superior control but not significantly higher than a single application in the spring. From these results it is apparent that *Dendrophoma* leaf blight can be significantly reduced by a single spray of an organic mercury applied in the spring when the plants are least susceptible to injury.

TABLE 3—Comparison of the number of applications required of Tag 331 for control of Strawberry Leaf Blight

Time of application	Percent of leaflet infection			
	Healthy	Mild	Moderate	Severe
Fall	43.8	31.6	14.4	10.0
Fall and Spring	77.7	20.5	1.6	0.0
Spring	75.0	19.4	4.4	1.1
Check	9.4	37.7	37.7	15.5

SUMMARY

The apparent increase of leaf blight in Michigan has resulted from large plantings of the susceptible strawberry varieties Senator Dunlap, Red Crop and Robinson. Preliminary trials indicated that an eradicant spray was of value in controlling strawberry leaf blight. Further tests showed that a single organic mercurial application was superior to a series of protective fungicide sprays.

Since phenyl mercury acetate and dinitro ortho cresolate formulations were common eradicative fungicides in commercial use, a comparison of the two for leaf blight control indicated the organic mercury was superior.

The time of application for economic control of a disease is considered just as important as the selection of the proper fungicide. Applications of Tag 331 at fall and spring periods showed that a single spray applied in early spring was the most economical.

RECOMMENDATION FOR CONTROL OF STRAWBERRY LEAF BLIGHT

1. Use an organic mercury at dosage recommended by the manufacturer.
2. Thorough coverage is essential, a rate of 150 to 200 gallons of spray per acre should give excellent control.
3. The timing for this single eradicant application is in early spring as the plants are beginning to break dormancy.

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A METHOD OF MECHANICALLY HARVESTING CORN RESEARCH PLOTS

By C. M. HANSEN and L. S. ROBERTSON[1]

DEPARTMENTS OF AGRICULTURAL ENGINEERING AND SOIL SCIENCE

HARVESTING CORN PLOTS is a laborious and time consuming task. Research on corn production is seriously limited when plots have to be hand harvested. The objections to this method of harvesting are: (1) high time requirement and man power costs; (2) measurable difference in accuracy of individual workers; and (3) poorer quality work done by the individual as the day progresses.

The field layout, design, and size of experimental plots eliminate the use of commercial corn pickers. Such pickers destroy much of the standing corn, are difficult to transport, and are not maneuverable enough for field plot work.

Analysis of the experimental corn plot harvesting problem suggested the following requisites:

1. Husking, weighing and sampling operations must be separated from picking.
2. The picker must be compact and light weight so that it can readily be transported from one part of the state to another.
3. The picker must be maneuverable because plots are small and frequently are a part of a farmer's field.
4. The equipment must have a large capacity because the harvest season is limited.
5. The picker must be narrow enough to operate satisfactorily in 36 inch rows without damaging the rows on either side.

[1]The authors wish to acknowledge the assistance rendered by the Tractor and Implement Division, Ford Motor Company, Birmingham, Michigan; Oliver Corporation, Battle Creek, Michigan; New Idea Farm Equipment Company, Coldwater, Ohio, through gifts of certain pieces of equipment.

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THE PICKER

To meet the above requirements, a commercial one row picking unit (Fig. 1) was mounted on an offset- tricycle -type carrier. Power for propulsion, hydraulic controls, and picker unit was furnished by a V-four cylinder air-cooled engine. The drive wheels on either side of the picker unit were equipped with 8:00 - 24 tractor tires. The machine was guided by individual wheel brakes and a single rear steering wheel which was off-set to trail behind the left-hand drive wheel (Fig. 2). Hydraulic cylinders actuated the picker head and the 5-bushel capacity ear corn bin.

The picker hydraulic controls, steering wheel, clutch and brakes were placed within easy reach of the operator. The governed forward speed is 1.52 miles per hour. The peripheral speed of the snapping rolls is 646 feet per minute.

THE HUSKING AND WEIGHING UNIT

The husking bed was built as a separate unit in order to minimize the weight and the over-all width of the picker. An eight roll husking bed powered by a 3 horse air-cooled gas engine was mounted on a

Fig. 1. Front view of corn picker in the field. Note the offset picker unit.

stake truck. An ear hopper was added to the husking bed to receive the corn from the picker.

The husked ears slide down a metal chute into a tub fitted with a trap door. The tub was suspended on heavy duty scales. Scales were fastened to a weighing boom which swings into any position in a 180° horizontal arc.

Space was provided on the truck for the addition of a sheller unit. When conditions are suitable, the ears can be shelled. This should reduce some of the experimental error and make sampling for moisture analysis easier.

THE METHOD OF USE

Experimental plots are frequently located in farmers' corn fields where the soil is uniform and where the opportunity for damage from unexpected sources, such as livestock and insects, is minimized.

Fig. 2. Front view without picker unit. Note that steering throttle and hydraulic controls are easily accessible.

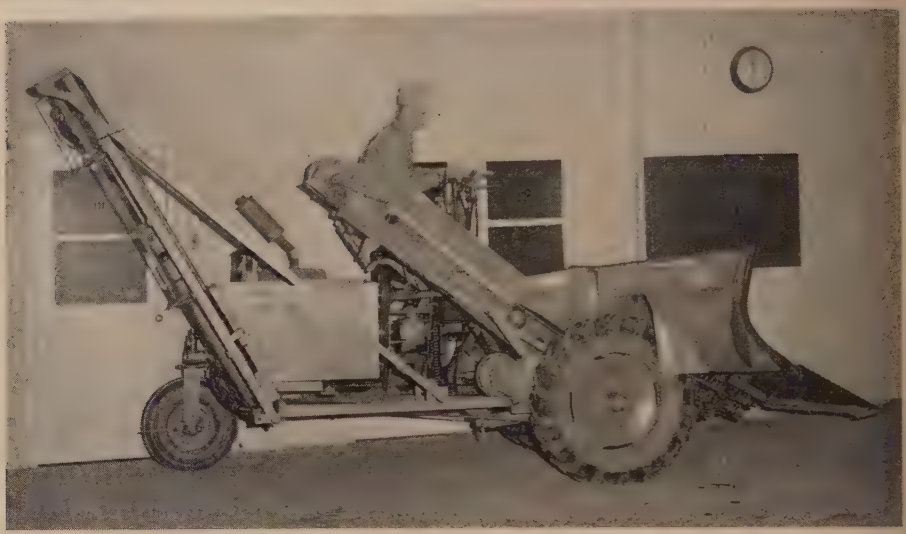

Fig. 3. View of the right side. The bin is in position for collecting ears from the snapping rolls.

Fig. 4. Here the ear bin is in an elevated and partially tipped position ready to dump the corn into the husker hopper. The trailer is used for transportation of the picker. Fig. 5 shows more detail of the dumping mechanism.

The plots can be located anywhere in the field, because with this picker it is now possible to pick a lane into the plots and not destroy any of the farmer's corn. Formerly, it was necessary to locate the plots on the edge and near the entrance to the field.

At the plot location, the picker is used on one plot at a time. It will not damage bordering rows which usually are left for the farmer to harvest. The picked ears are mechanically deposited into the ear bin (Fig. 3). The picker is backed up to the truck on which the husking unit is mounted. A hydraulic system elevates and empties the contents into the ear hopper of the husker (Fig. 4, 5). The corn passes over husking rolls and into a tub with a trap door. Weights are recorded and samples for moisture obtained (Fig. 6). The tub is then pivoted on the boom over to a wagon and emptied. Husking, weigh-

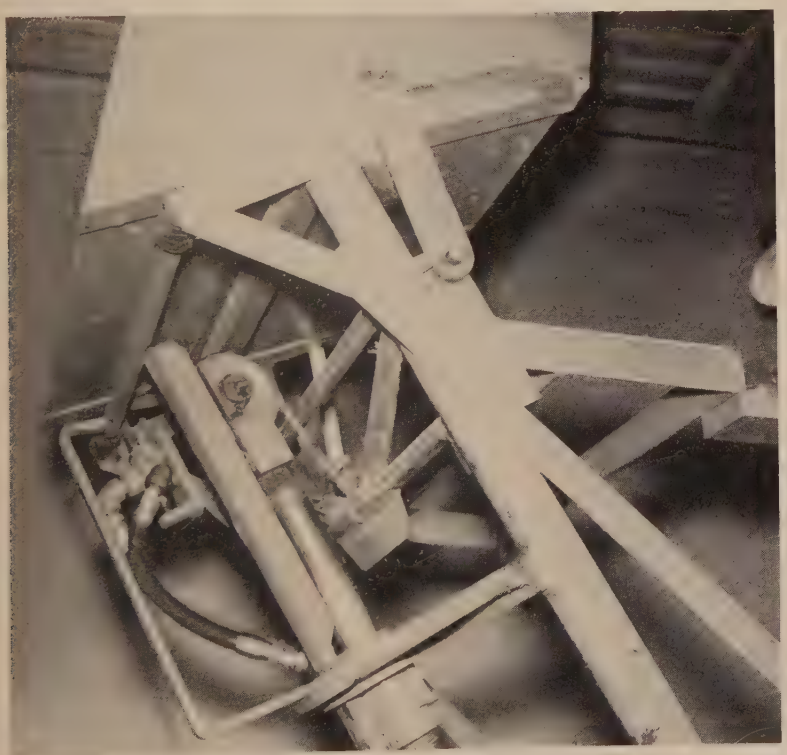

Fig. 5. Bin completely dumped. Note the safety valve on the hydraulic cylinder line which terminates thrust. Sufficient thrust is given bin to empty it.

Fig. 6. This is the husking, weighing and sampling set up which is all mounted on a truck. Note the gasoline motor used to power the husker and the weighing boom which swings into any position within a 180 degree arc.

ing and sampling requires less time than is needed for the picker to harvest and return with another load. Harvesting by this method is reduced to a two man job.

Tests in 1954 show that in standing corn, the picker was 99.2 percent efficient. This factor is dependent upon working conditions and adjustment of the picker. Experience has shown that this system of harvesting corn takes less physical labor and less time. In several instances, more accurate results were obtained.

SPRAYING TOMATOES WITH FIXED COPPERS AND CARBAMATES[1]

By M. C. STRONG[2]

Department of Botany and Plant Pathology

During a 5-year study of the control of leaf blights and anthracnose on tomato, the author has reported[3,4] the advantages of spray combinations of various fixed coppers and ziram (zinc dimethyldithio carbamate) over either fungicide used separately or in an alternating spray schedule.

Recently other workers have described similar results with various crops. Beecher[5] obtained good control of downy mildew and angular leaf spot on cucumber and downy mildew on melons with tank mixtures of tribasic copper sulfate and a dithiocarbamate. French investigators[6] found a synergistic effect between zineb and copper in controlling downy mildew on grape.

This paper describes the 1953-1954 tests with various fungicides on tomatoes and is a continuation of the work previously reported. The methods of culture employed and the manner of obtaining data have already been described.[7] Southern grown plants of the Rutgers variety were used in all plots.

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[1]Contribution 55-4 from the Department of Botany and Plant Pathology, Michigan State College.

[2]The author wishes to thank the several agricultural chemical companies that furnished fungicides and financial assistance for these tests.

[3]Strong, M. C. (1951). Preliminary tests of fungicide combinations in tomato sprays and dusts. Mich. Agr. Expt. Sta. Quart. Bul. 33:320-325.

[4]Strong, M. C. (1953). Fungicide combinations in tank-mix sprays for tomatoes. Mich. Agr. Expt. Sta. Quart. Bul. 35:440-449.

[5]Beecher, F. S. (1955). Control of downy mildew on cucumbers and muskmelons with tank mixtures of a fixed copper and a dithiocarbamate. Plant Dis. Rept. 39:220.

[6]Payen, B., B. Thellot, and J. Thiolliere (1954). Mise en evidence d'une synergie entre le zineb et les produits cupriques dans la lutte contre le mildiou de la vigne. Academie d'Agriculture de France. Extrait du proces-verbal de la seance du 28 Avril 1954.

[7]Strong, M. C. (1950). Comparison of fungicidal sprays for the control of tomato blights. Mich. Agr. Expt. Sta. Quart. Bul. 32:338-347.

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1953 TEST

In 1953, four kinds of fixed coppers and three forms of ziram were tested in various combinations. A combination of fixed copper and zineb was also tested both as a tank mix and as a reaction product.

Plants were set in the field May 20. Six spray applications were made between July 10 and September 14 at 10 to 14 day intervals. Methoxychlor was added to the first two spray applications for hornworm control. Check plots received two applications of this insecticide only. The first picking was made August 5th followed by 12 more.

Killing frost occurred October 7. *Alternaria* (early) blight was first observed on July 10 and *Septoria* blight appeared two weeks later. Both of these diseases were abundant in the untreated control plots. Fruits infected with late blight, collected in commercial plantings, were scattered in the experimental field on two occasions. However, no late blight developed on the plants because weather conditions became unfavorable for this disease. Anthracnose appeared late in August and was present the remainder of the season.

Yields were very good in spite of the dry season. There was plenty of soil moisture at planting time. Later, rainfall was supplemented by irrigation. The culls represented losses mainly due to anthracnose and blight but also included losses caused by blossom-end rot, *Rhizoctonia* soil rot, and cornborer and tarnished plant bug damage. The data obtained are summarized in Table 1.

DISCUSSION OF RESULTS

All of the fixed copper combinations with ziram gave good control of *Septoria* blight, whereas applications of ziram alone resulted in little control of this disease. Tank mixes of fixed copper and ziram controlled anthracnose much better than did the alternating schedule of the same fungicides.

Applications of tribasic copper sulfate in a tank mix with zineb resulted in good blight and anthracnose control and a good yield, but did not exceed the effectiveness of a tank mix with the same fixed copper and ziram. The tank reaction product of tribasic copper sulfate and ziram was superior to the reaction product of zineb and tribasic copper sulfate.

Copper oxide, copper oxychloride sulfate, tribasic copper sulfate and Cop-o-zink were equally effective in the tank combinations. The

Table 1—Summary of 1953 tomato fungicial spray trials

Treatment	Formula	Total yield tons per acre	Percentage culls	Percentage defoliation 9-25-53
Control	Untreated	12.2	40.2	95.0
*Robertson copper + ZC‡ (alternating)	2.15 lb., 2 lb.—100 gal.	18.8	15.1	45.0
Robertson copper + ZC (tank mix)	1.07 lb. + 1 lb. – 100 gal.	18.5	12.8	40.0
†Tribasic copper sulfate + ZC (alternating)	4 lb., 2 lb.—100 gal.	19.4	13.3	49.3
Tribasic copper sulfate + ZC (tank mix)	2 lb. + 1 lb.—100 gal.	19.3	12.0	40.1
Tribasic copper sulfate + ZC (reaction product)	2 lb. + 1 lb.—100 gal.	19.4	15.9	45.5
†Cop-o-zink + ZC (alternating)	4 lb., 2 lb.—100 gal.	18.4	14.2	46.2
Cop-o-zink + ZC (tank mix)	2 lb. + 1 lb.—100 gal.	18.6	13.5	42.5
‡COCS + Vancide 51ZW (tank mix)	1½ lb. + 1 lb. – 100 gal.	20.2	13.1	35.5
COCS + ZC (tank mix)	1½ lb. + 1 lb.—100 gal.	19.1	12.2	48.8
§Vancide 51ZW (zinc salts)	2 lb.—100 gal.	17.1	22.9	55.0
Vancide F 1030 (ammonium salts)	3 lb.—100 gal.	18.4	25.0	69.4
Vancide F 407 (calcium salts)	3 lb.—100 gal.	19.4	21.0	60.0
‖Coro SDD + $ZnSO_4$ (tank mix)	1 qt. + 1 lb. – 100 gal.	18.6	23.2	45.3
Coro SDD + Tribasic copper sulfate (tank mix)	1 qt. + 2 lb.—100 gal.	18.8	18.0	50.0
Tribasic copper sulfate + Z78** (tank mix)	2 lb. + 1 lb.—100 gal.	19.0	15.6	50.0
Tribasic copper sulfate + Z78 (reaction product)	2 lb. + 1 lb.—100 gal.	17.2	28.1	56.0
L. S. D. (at 1% level)		1.4	3.9	7.1

*Manufactured by H. H. Robertson Company.
†Manufactured by Tennessee Corporation.
‡Manufactured by Niagara Chemical Division of Food Machinery & Chemical Corporation.
§Manufactured by R. T. Vanderbilt Company.
‖Manufactured by Corona Chemical Division of Pittsburg Plate Glass Company.
**Manufactured by Rohm & Haas Company.

same was true of the three types of ziram tested, Z-C, Coro-SDD and Vancide 51 ZW (zinc salts of dimethyldithio carbamic acid and 2 - mercaptobenzothiazole).

The tank mix of Coro-SDD and tribasic copper sulfate was equally as effective in disease control as the tank mix of Coro-SDD and zinc sulfate. Applications of Vancide F 407 (the calcium salts) resulted in higher yields than applications of Vancide 51 ZW (zinc salts) or Vancide F 1030 (ammonium salts) alone but did not equal the tank mix of Vancide 51 ZW and COCS.

1954 TEST

The 1954 test was similar in design to the previous trials. The length of the season was almost identical with that in 1953. Sprays were timed about the same. *Alternaria* and *Septoria* blights as well as anthracnose appeared at the same time as in 1953 and were prevalent during the remainder of the season. Attempts at inoculation with late blight failed as in the previous summer because of unfavorable weather conditions for the development of this disease. Irrigation was not used in 1954. The results obtained are recorded in Table 2.

DISCUSSION OF RESULTS

In general, yields were fairly high. All spray treatments resulted in significant increases in yield over the untreated controls.

Applications of four kinds of fixed copper with ziram in a tank mix, as compared with the same fungicides in an alternating schedule, varied only slightly in effect on yields obtained; but the tank mix gave better control of anthracnose in each case.

Copper oxychloride sulfate plus Vancide Z-65 (zinc salts of dimethyldithio carbamic acid and of 2 - mercaptobenzothiazole) in a tank mix gave a statistically significant increase in yield over either fungicide alone. Vancide F 965W (the iron salts of Vancide) alone, or in a tank mix with copper oxychloride sulfate, was less effective in increasing yield than the fixed copper alone. The iron salts of Vancide left an undesirable black residue on the fruit. Vancide 51 Ca (the calcium salts) alone was more effective than either the zinc or iron Vancide alone.

Coro-SDD plus zinc sulfate was similar to Vancide Z-65 in effect on yield. Neither one gave good control of *Septoria*, but both were effective against anthracnose and early blight. Coro-SDD plus copper

TABLE 2—Summary of 1954 tomato fungicidal spray trials

Treatment	Formula	Total yield tons per acre	Percentage culls	Percentage defoliation 9-20-54
Control	Untreated	12.3	40.7	65.5
*Crag 658+ZC‖ (alternating)	2 lb., 2 lb.,—100 gal.	18.9	11.3	17.2
Crag 658+ZC (tank mix)	1 lb.+1 lb.,—100 gal.	19.4	10.2	14.7
†Tribasic copper sulfate+ZC (alternating)	4 lb., 2 lb.,—100 gal.	19.2	12.1	17.0
Tribasic copper sulfate+ZC (tank mix)	2 lb.+1 lb.,—100 gal.	19.8	10.0	10.5
†Tribasic copper sulfate (with Mn)+ZC (alternating)	4 lb., 2 lb.,—100 gal.	19.4	10.3	17.5
Tribasic copper sulfate (with Mn) + ZC (tank mix)	2 lb.+1 lb.,—100 gal.	18.8	11.5	15.9
†Cop-o-zink+ZC (alternating)	4 lb., 2 lb.,—100 gal.	19.2	10.6	21.0
Cop-o-zink+ZC (tank mix)	2 lb.+1 lb.,—100 gal.	18.4	10.9	14.7
‡Coro-SDD+$ZnSO_4$ (tank mix)	1 qt.+1 lb.,—100 gal.	17.0	14.9	35.1
Coro-SDD+$CuSO_4$ (tank mix)	1 qt.+1 lb.,—100 gal.	16.6	13.2	27.5
§Dithane+$ZnSO_4$ (tank mix)	2 qt.+¾ lb.,—100 gal.	17.8	12.7	25.0
Dithane+$MnSO_4$ (tank mix)	2 qt.+1 lb.,—100 gal.	18.9	10.9	20.5
§He 177 (Copper carbamate)	2 lb.,—100 gal.	19.0	10.0	13.2
§M 22 (Maneb)	2 lb.,—100 gal.	19.1	10.2	17.7
‖COCS	3 lb.,—100 gal.	17.6	11.2	16.2
COCS+Vancide Z 65 (tank mix)	1½ lb.+1 lb.,—100 gal.	19.3	10.1	16.2
**Vancide Z 65 (zinc salts)	2 lb.,—100 gal.	17.2	14.1	30.6
**Vancide F965 W (iron salts)	2 lb.,—100 gal.	13.8	19.7	40.2
COCS+Vancide F 965 W (tank mix)	1½ lb.+1 lb.,—100 gal.	14.6	17.3	25.7
**Vancide 51 Ca (Calcium salts)	4 lb.,—100 gal.	18.6	12.3	29.5
L. S. D. (at 1% level)		.8	3.1	5.2

*Manufactured by Union Carbide and Carbon Corporation.
†Manufactured by Tennessee Corporation.
‡Manufactured by Corona Chemical Division of Pittsburg Plate Glass Company.
§Manufactured by Rohm and Haas Company.
‖Manufactured by Niagara Chemical Division of Food Machinery & Chemical Corporation.
**Manufactured by R. T. Vanderbilt Company.

sulfate offered some promise, but the formula, as used, was not quite satisfactory. A similar difficulty was encountered in a previous attempt to combine Dithane 14 and copper in a tank mix.

There was little difference between the effects of powdered maneb (M-22) and Dithane plus $MnSO_4$. The copper salt of nabam (Hel77) was the equal of the manganese salt and both were superior to the zinc salt in increasing yields and controlling disease.

CONCLUSIONS

Even in seasons when late blight is not present, tomato yields may be increased by 50 percent, or more, by controlling *Alternaria* and *Septoria* blight. These diseases are not always regarded as serious but they gradually defoliate the plants with a resultant reduction in yield and grade of fruit produced. Anthracnose, the ripe fruit rot, also takes an annual toll in unsalable fruit. Applications of fixed copper in a tank mix with either ziram or zineb gave good blight and anthracnose control on tomatoes. However, a tank mix of fixed copper and ferbam was inferior to the fixed copper alone.

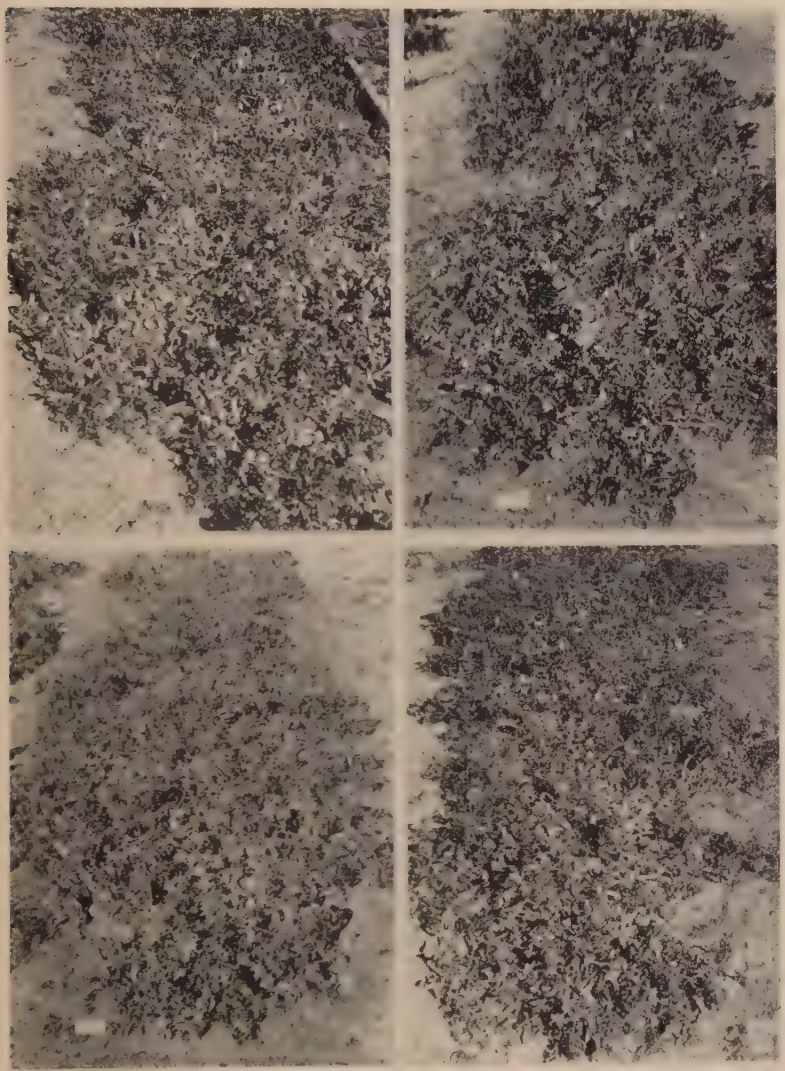

Fig. 1. Comparison of tomato plots sprayed with three different fixed coppers plus ziram in a tank mix, and a comparison of plots sprayed with a fixed copper and ziram in a tank mix and in an alternating schedule. Upper left, Crag 658 + Z-C (tank mix); upper right, Cop-o-zink + Z-C (tank mix); lower left, tribasic copper sulfate + Z-C (tank mix); lower right, tribasic copper sulfate and Z-C in an alternating schedule. (Unsprayed plot shown in Fig. 3)

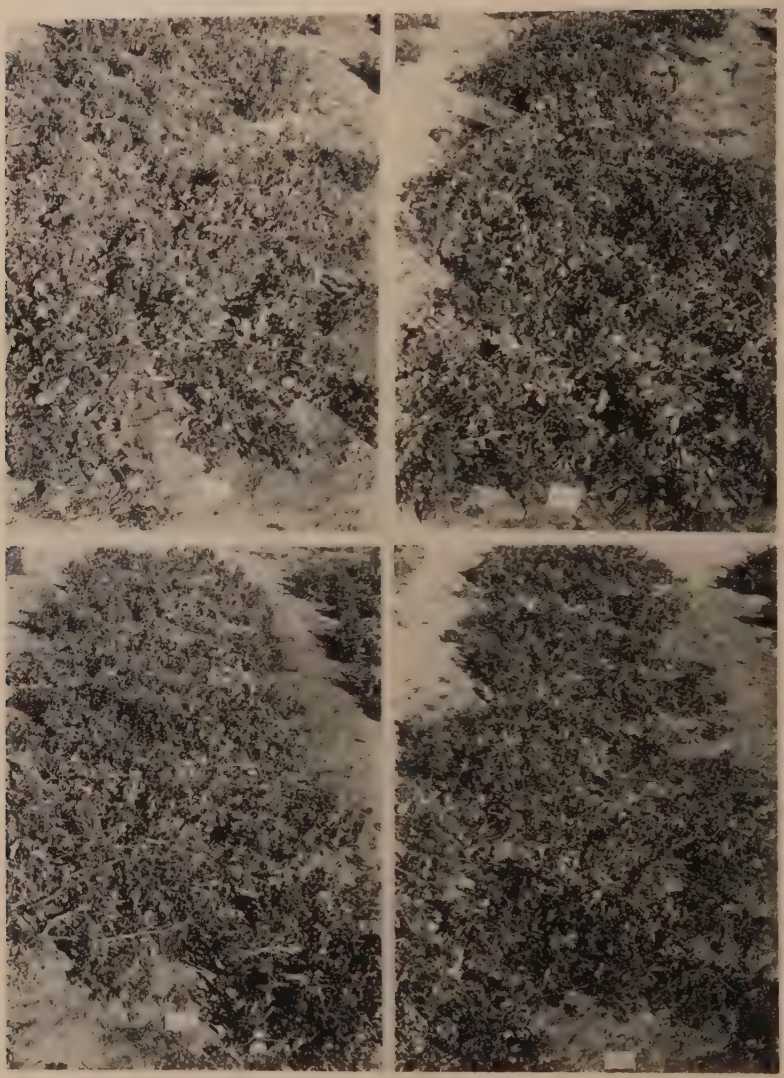

Fig. 2. Comparison of tomato plots sprayed with a fixed copper alone, ziram alone and a tank mix of the two fungicides, also a tank mix of a fixed copper and ferbam. Upper left C-O-C-S, upper right Vancide 65Z, lower left C-O-C-S + Vancide 65Z, lower right C-O-C-S + Vancide F965. (Unsprayed plot shown in Fig. 3)

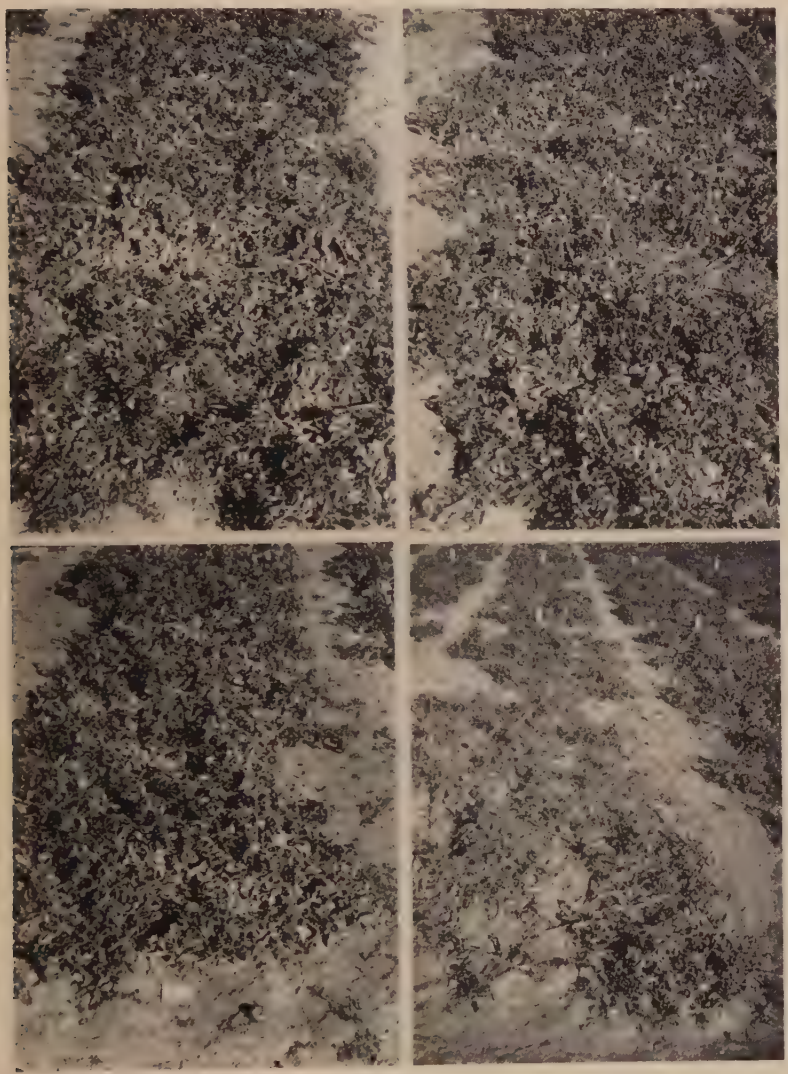

Fig. 3. Comparison of tomato plots sprayed with Coro-SDD + $ZnSO_4$, upper left; Coro-SDD + $CuSO_4$, upper right; nabam + $CuSO_4$ (He 177), lower left; and lower right, untreated control plot.

LEAF ANALYSIS AS A GROWER SERVICE IN MICHIGAN

By A. L. KENWORTHY
Department of Horticulture

Leaf analysis was first used in Michigan to diagnose fertilizer needs of fruit crops in 1950. It was continued on a trial basis from 1950 to 1954. In 1954, leaf analysis was established as a service for the fruit growers of Michigan in much the same manner as soil testing serves Michigan farmers.

The procedure for leaf analysis begins by the growers collecting leaf samples according to instructions. When air dried, the samples are sent to the Horticulture Department of Michigan State College where they are prepared for analysis. The prepared samples are then sent to the agriculture chemistry laboratories where analyses are made for nitrogen (Kjeldahl), potassium (flame photometer), and spectrographically for phosphorus, calcium, magnesium, manganese, boron, copper, and iron.

Analytical data are then sent to the horticulture department for interpretation. The interpretation is placed on a Nutrient-element Balance Chart which is sent to the grower with a letter containing suggestions on fertilizer usage.

During the four trial years, approximately 150 leaf samples were received. In 1954, the year of formal establishment, 184 samples were received from 79 growers in 27 counties (Fig. 1). A total of 82 samples were received from Berrien, Van Buren, Grand Traverse, and Leelanau counties where there are probably more instances of erratic fertilizer responses than elsewhere in the state.

The use of leaf analysis to determine fertilizer needs of fruit crops permits the detection of: (1) a nutrient shortage prior to the occurrence of deficiency symptoms, and (2) the excessive use of fertilizers.

Table 1 shows the frequency of occurrence of shortages and excesses of the nutrient-elements determined for the 1954 samples.

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Only 3 percent of the samples showed deficiency symptoms, but hidden deficiencies were numerous. The low frequency of shortages indicates that the use of nitrogen is well-regulated. The large number of samples showing shortages of potassium, phosphorus, and magnesium was in line with known conditions. However, the number of samples showing shortages of manganese, iron, and boron was above that which was expected and suggests that there may be a widespread shortage of these nutrients.

Excesses were much less numerous. Excessive usage of potassium was found in 18.4 percent of the samples, and an above-normal level

Fig. 1. Counties from which leaf samples were received by the Grower Service in 1954.

TABLE 1—The occurrence of nutrient-element deficiencies and excesses for the fruit tree leaf samples analyzed for fruit growers

Nutrient-element	Percent of samples				
	Deficient	Hidden deficiency	Normal	Approaching excess	Excess
Nitrogen	0	23.5	75.9	0.6	0
Phosphorus	0.6	44.8	33.9	11.5	9.2
Potassium	1.7	20.7	55.2	18.4	4.0
Calcium	0	17.2	58.0	19.5	5.2
Magnesium	0.6	41.9	48.3	7.5	1.7
Manganese	0	41.9	24.8	8.6	8.0
Iron	0	53.4	33.3	8.6	4.6
Boron	0	66.8	31.0	1.1	1.1
Copper	0	9.4	71.3	9.9	9.4

of calcium was found in 19.5 percent. Manganese excess was found in 8.6 percent of the samples, and manganese toxicity symptoms were reported for some of the samples.

The results indicate that leaf analysis holds considerable promise as an improved method of determining the fertilizer needs of fruit crops. The present Grower Service is established for apple, pear, peach, and cherry. Grapes, blueberries, strawberries, raspberries, and other fruit crops will be added as soon as possible.

HARVESTING AND RIPENING FREESTONE PEACHES FOR PROCESSING[1]

By C. L. BEDFORD and W. F. ROBERTSON
DEPARTMENT OF HORTICULTURE

FREESTONE PEACHES are capable of yielding a choice processed product, either canned or frozen. However, to obtain this choice product it is essential that the peaches be picked at the right stage of maturity. The maturity at harvest will determine not only the flavor and quality of the processed product, but will also determine the overall yield in the orchard and the pack-out yields in the processing plant. With close cooperation between the grower, the picker, and the processor, a profit is assured.

WHEN TO PICK

Research studies have shown that best flavor and quality in canned and frozen peaches is attained when the peaches are harvested at a maturity requiring 3 to 7 days of ripening at 70° - 75° F. Peaches harvested at a more mature stage lack good peach flavor and tend to be soft and fibrous; peaches requiring 8 or more days to ripen are characterized by an astringent and tart flavor. Therefore, the ultimate goal is to pick freestone peaches within the proper maturity range.

GROUND COLOR

High color is not a sign of satisfactory ripeness. It is only a guide and must be used as such. It may be confusing, since a red-checked peach may be actually green. Peaches with ground color of the same shade of yellow may not be of the same degree of ripeness. Ground color fluctuates from year to year and from orchard to orchard. In

[1]For more detailed information see Bedford, C. L. (1955). Harvest maturity and ripening of peaches in relation to quality of the canned and frozen product. Mich. Agr. Expt. Sta. Tech. Bul. 245. 31 pp.

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some years and in some orchards, it is greener than others. Usually, during the same season and in the same orchard, ground color is fairly uniform. Therefore, consider only the orchard being picked.

FIRMNESS

Firmness, as measured by the pressure tester, seems to be fairly closely associated with maturity. It is difficult to establish precise standards that are completely valid every year. However, data obtained indicates that peaches testing more than 12 pounds on the pared checked with a 5/16 inch plunger are too immature. Therefore, peaches should be picked only when the firmness is 12 pounds or less.

HOW TO TELL WHEN TO PICK

Knowing when to pick may seem difficult after picking more or less by guess. By checking firmness and ground color, picking can be made easier.

1. Use the pressure test to determine the stage of maturity.
2. Determine the range of ground color that corresponds to a pressure test of less than 12 pounds.
3. Instruct pickers as to the range of ground color desired.
4. Do not rely on blush color as an index to maturity.
5. Remember that color varies from season to season and tree to tree.

MORE THAN ONE PICKING IS USUALLY NEEDED

Since each peach tree does not ripen all of its fruit at the same rate, more than one picking will be necessary to obtain fruit in the proper maturity range.

Extra pickings mean greater picking costs, but result in greater tonnage. When pickings are spaced 3 days apart, fruit increases in weight up to 10 percent. This added weight usually makes up for the additional expense.

RIPENING

Since it is not practical to harvest tree-ripened fruit for commercial processing, it is necessary to ripen the fruit after harvesting. The ripening procedure greatly affects the dessert quality of the processed product.

For best quality, peaches should be ripened at a temperature of 70° to 75° F. Peaches ripened at higher temperatures will develop a

stale or over-ripe flavor before they reach processing ripeness, and this flavor will be apparent in the processed product.

Fruit must be ripened until all green color has disappeared in order to avoid off color in the final product, and to assure the best flavor. When the fruit is properly picked, 3 to 7 days will be required for proper ripening.

CULTURAL PRACTICES IN PROPAGATING DWARFING ROOTSTOCKS IN MICHIGAN

By R. F. CARLSON and H. B. TUKEY
DEPARTMENT OF HORTICULTURE

INCREASING DEMAND from both commercial fruit growers and nursery operators for semi-dwarf trees and dwarfing rootstocks has necessitated continued development of cultural methods for increasing the desirable rootstocks on a commercial scale. Dwarfing apple rootstocks of the East Malling series have been used extensively in field studies for about 10 years at East Lansing. Further, the certification[1] program initiated in 1950 for the distribution of true-to-name dwarfing rootstocks to chosen nurseries has called for close attention and critical evaluation of all phases of the problem. This report deals with some of the methods and practices followed in the production of quality rootstocks.

MATERIALS AND METHODS

Since 1945, the experimental planting at East Lansing has been increased from a small number of foundation stocks to approximately 4 acres. This planting now comprises the entire series of East Malling stocks, as well as various quince and plum stocks. The major portion of the planting is composed of EM I, II, VII, IX, XII, XIII, and XVI since they show considerable promise for either private or commercial tree plantings.

Original plants were set about 12 inches apart in rows 9 feet apart, in order to facilitate the use of conventional tillage equipment and to provide adequate soil for mounding. The rootstock was allowed to grow for one year to become well established before mounding.

The soil, a Hillsdale sandy loam, was suitable for mounding and

[1]The certification program is a cooperative venture of Michigan State College and the Michigan Department of Agriculture (Bureau of Plant Industry).

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growing of the stock. About one inch of organic muck was applied annually in a 14-inch band over the row to hold the water which is so essential for root formation. In addition, some manure was spread between the rows with a manure spreader. The planting also received an annual overall application of a complete fertilizer (10-10-10) at the rate of 350 to 400 pounds per acre. Supplementary irrigation was used in the planting for the last 4 years.

Routine sprays for insects and diseases were made several times during the growing season. Aphids, leaf hoppers, and apple scab caused the most trouble. Weeds were controlled with timely use of herbicides and some hoeing.

MOUNDING PROCEDURES

In March, one year after planting, the top growth of the rootstock was cut off at ground level to force several shoots below the cut. When

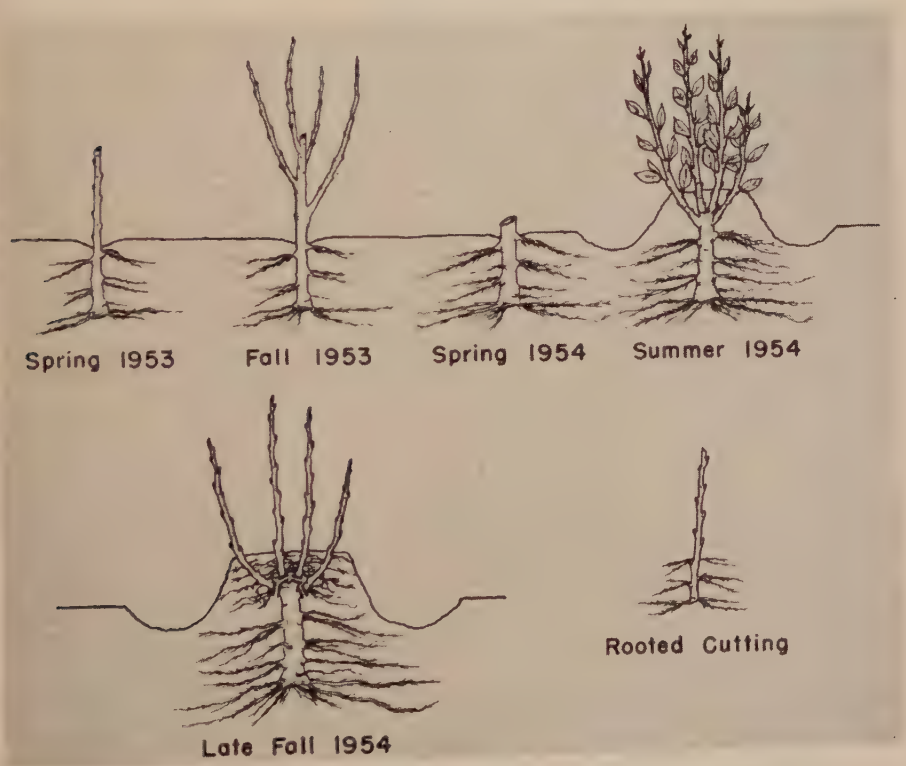

Fig. 1. Propagation of Malling rootstock by the mound system, showing the various steps in the production of a rooted cutting.

these new shoots were about 12 inches tall and still tender and succulent, they were mounded to a height of 6 inches. Later, in July, they were mounded again so that the final mound was about 12 to 15 inches high in the center of the row.

A one-bottom plow was used to push the soil around the shoots, forming the mound. One man usually followed with a hoe, pulling soil more closely around plants that were not reached with the plow. The soil was mounded high enough to allow for settling; however, 6 to 10 inches of the tips were left showing above the mound (Fig. 1).

REMOVAL OF ROOTED SHOOTS

In November, before the soil froze, most of the mound was pulled down with a plow. The soil next to the shoots was removed carefully, either with a shovel or hoe. Then all shoots were cut at the point of origin, making no cut higher than the original one in March. The exposed cut surfaces of the "stools" were covered with an inch of soil for protection during the winter. The shoots were kept separate according to number of stock, and were taken to the nursery storage for processing and grading.

This procedure has been repeated annually, except in cases where the stock was low in vigor and was allowed to grow for one year, with no shoots removed.

INSECTS AND DISEASES

Leaf hoppers and aphids were controlled with timely sprays of parathion and nicotine sulfate. Fermate was included for scab control.

During the 1953 and 1954 season, woolly aphids became troublesome on some of the stocks. EM I, IV, VII, and IX seemed most susceptible to attack, whereas EM II, XII, XIII, and XVI showed some resistance.

Materials such as chlordane and aldrin, applied to the soil at the base of the plants, have been suggested as control measures of woolly aphids. Annual applications over a few years may be necessary to control or eliminate this pest. Moderate woolly aphid injury on a well-rooted cutting is not serious, since it will outgrow the injury. Severely injured cuttings must be discarded (Fig. 2).

An occasional plant has been found infected with crown gall; however, persistent roguing has kept the planting comparatively free of this disease.

DISCUSSION

A soil high in fertility and organic matter apparently is essential for satisfactory growth and production of well-rooted cuttings. In rows where fertilizers and organic matter were limited, the stools were noticeably lower in vigor over the 10-year period. In establishing a new stool-bed planting for propagation purposes, it is important first to consider a soil that is easily tillable, high in organic matter, and retentive of moisture. A heavy clay soil should be avoided.

Fig. 2. Woolly aphid injury on roots and stems of Malling IX. Severely infested (left) and moderately infested (right). Severely infested material should be destroyed.

Fig. 3. Irrigation of a planting of East Malling rootstock in August. Note the standpipes holding the nozzles about 4 feet above the mound for more complete coverage.

Moisture in the soil mound is of prime importance. Where the rows run east and west, the south side of the mound is exposed to direct sun for 10 to 12 hours daily, causing rapid drying out. Placing the rows in a south-north direction alleviates this situation to some extent.

Supplementary water in the form of overhead irrigation appears to be essential under Michigan conditions. Often the months of August, September, and October are deficient in rainfall. Timely applications of water during these months when growth and rooting occur not only increase vigor but also produce better-rooted shoots.

In order to cover a sufficient area over the mounds per "setting" of irrigation pipes, a standpipe for each sprinkler was necessary. These standpipes were made from one-inch piping, 4 feet high, and supported with a wooden stand (Fig. 3). By placing the pipes between the rows, each "setting" covered about 6 rows. Enough water was applied to prevent drying out and to keep the soil moist.

The different clones of the East Malling series rooted satisfactorily with the procedure described (Fig. 4). Malling I, VII, and XIII produced the greatest number of well-rooted shoots, whereas Malling II, IX, XII, and XVI were not quite as productive.

The shoots of each clone were graded into three classes: well-rooted, few roots, and no roots. Only the well-rooted stock was dis-

Fig. 4. Typical well-rooted shoots of EM II, VII, and IX (left to right). Cuttings were removed from the mound in November.

tributed to nurseries as part of the certification program for establishing stool beds.

SUMMARY

1. During the past 10 years (1945-55), true-to-name dwarfing rootstocks of the East Malling series have been grown and propagated in Michigan with reference to improved cultural practices and use of orchard studies; and distributed to nurserymen as part of a newly-formed certification program.

2. An easily worked soil, rich in fertility and high in organic matter, proved most satisfactory for good growth and production of well-rooted shoots.

3. Supplemental water from overhead irrigation was found beneficial, especially in the fall when soil moisture was required for good root formation in the mound.

4. A regular and systematic insect and disease spray program in the stool bed was found essential.

5. Woolly aphids were prevalent in some of the stocks in 1954. EM I, IV, VII, and IX showed more woolly aphid injury than II, XII, XIII, and XVI. A control program has been initiated.

6. Crown gall infestation has been kept at a low level by roguing and sanitation.

A PRELIMINARY REPORT OF INVESTIGATIONS OF SUBSIDENCE OF ORGANIC SOILS IN MICHIGAN

By J. F. DAVIS and C. A. ENGBERG[2]

THE CULTIVATION of organic soils is accompanied by a lowering of surface elevation. Oxidation, compaction, height of water table, temperature, burning, shrinkage, wind and water erosion, and geologic subsidence are factors associated with this phenomenon. Losses of elevation of one inch per year for over 100 years have been reported from the fens of England (Powers, 1932). Tule deposits in central California have subsided at the rate of 2 inches per year (Weir, 1950). The practice of burning for weed control has accentuated this rate of loss.

Losses of 6 to 7 feet in elevation in 40 years have occurred under Florida conditions with oxidation being the most important causal agent (Clayton, et al., 1942) (Neller, 1944). Subsidence rates of 0.45, 0.7 and 1.2 inches were reported in Indiana (Jongedyk, et al, 1950) where the water tables were at 17, 27, and 39 inches respectively. Minnesota data (Roe, 1936) indicate a subsidence of 6 inches and 2 feet where the average water tables were at 1 foot and 4.5 feet, respectively. It is predicted (Stephens and Johnson, 1951) that, because of subsidence, the Everglades peatland will become generally unfit for agriculture in less than 50 years.

PROCEDURE

A preliminary study was begun in 1948 to determine the amount of subsidence of organic soils to be expected in Michigan. It was planned also to attempt to correlate subsidence (within the limits of

[1]Joint contribution from the Soil Science Section of the Michigan Agricultural Experiment Station, East Lansing, Michigan, and the Soil Conservation Service, United States Department of Agriculture.

[2]Department of Soil Science, Michigan State College, Soil Conservation Service, United States Department of Agriculture, respectively.

Appreciation is expressed to personnel of the Michigan Hydrologic Research Station (Michigan Agricultural Experiment Station in cooperation with Agricultural Research Service, U. S. Department of Agriculture) for assistance in the study.

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such a preliminary study) with height of water table, pH, cropping practices, and other physical characteristics and conditions.

Field observations were conducted at 13 sites (Fig. 1) in Ionia, Ingham, Jackson, Lapeer, Livingston, and Sanilac Counties. Three soil types representative of the cultivated organic soils in the state—Carlisle Muck, Houghton Muck and Rifle Peat—were included.

Carlisle Muck is developed from mixed woody and grassy or sedgy organic material. It is well decomposed to depths of at least 12 inches

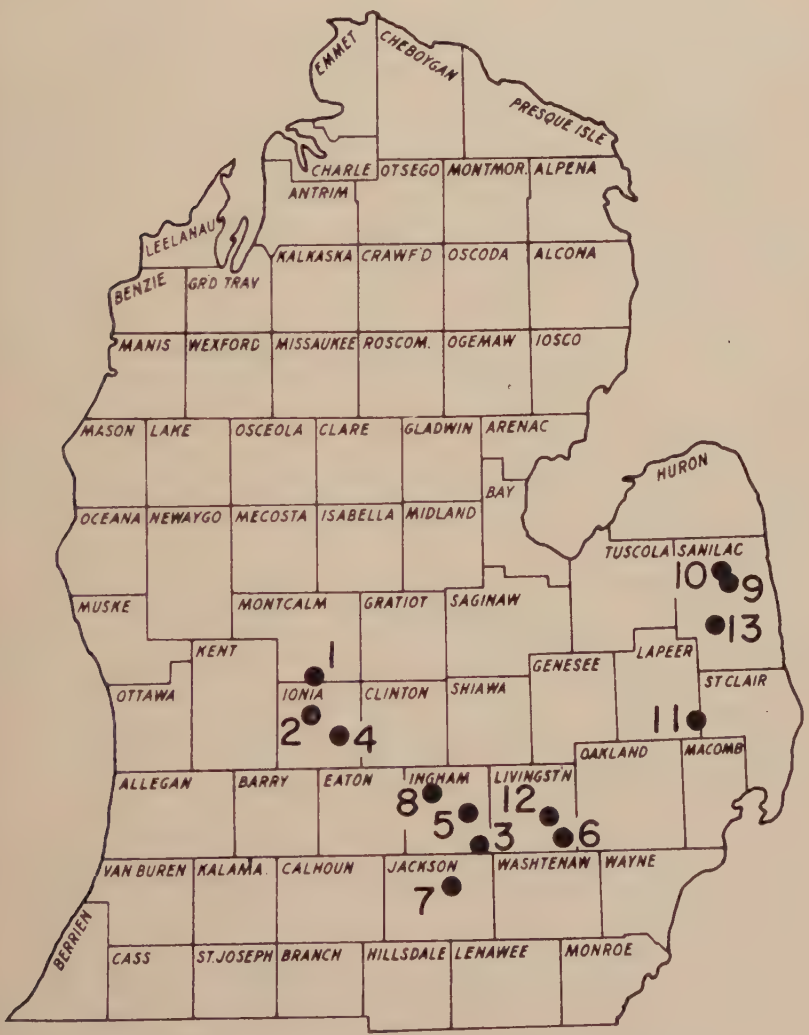

Fig. 1. Geographic locations of subsidence sites.

and underlain by undecomposed brown fibrous or woody material. The reaction ranges from pH 5.0 to pH 7.0.

Houghton Muck is developed from fibrous organic material containing little or no woody material, and is slightly to well decomposed to a depth of at least 12 inches. The reaction ranges from pH 5.0 to pH 7.0.

Rifle Peat is developed from mixed woody and grassy or sedgy materials. It is brown to yellowish brown, and is slightly to moderately well decomposed. The reaction ranges from pH 4.5 to pH 6.5.

To obtain elevations, a permanent bench mark was established, and profile levels were run annually or as frequently as seemed desirable. Suitable survey methods for a study of this type have not been previously developed, so two methods of profiling were employed. In one, parallel lines of levels were run across the site. In the other, which was found to be more satisfactory, a triangular compass traverse was run from the reference point in order to give a more complete coverage of the field.

In both cases, elevations for distances of 400 to 1,500 feet were taken at 25-foot intervals across the fields. Readings were also made at 10- and 25-foot intervals between elevation points at sites 5b and 5c to determine a suitable standard.

No significant difference was found between average elevations obtained with profile intervals at 10 feet and 25 feet (5b and 5c, 1948), so a 25-foot interval was adopted as standard. Numerals and letters designate those sites in which two or more traverses were made in the same field.

Soil samples at three depths (0-6, 12-24, and 36-42 inches) were taken along the traverse lines, and pH determinations made. Cropping histories, soil types, and depths of organic soil were recorded for each site.

RESULTS AND DISCUSSION

The characteristics of the sites are reported in Table 1. The areas represented a number of different types of situations, ranging from continuous pasture to continuous fallow.

As shown by the data reported in Table 2, subsidence ranged from 0.0 to 0.7 feet, with little correlation between the rate of subsidence and soil type. At sites 9, 10, and 13, the data indicate a peak rate of subsidence during the first years following breaking, after which the rate decreased gradually. At other sites a more gradual subsidence

TABLE 1—Physical characteristics of locations investigated

Site No.	Location	Drainage*	Soil type	pH**			Year broken	Depth feet	Crops***
				0–6"	12"–24"	36"–42"			
1	Sheridan.....	B	Carlisle Muck .	7.3	6.6	5.3	1948	3.5	Carrots (4), Onions (2)
2a	Ionia.....	B	Carlisle Muck .	4.8	5.5	5.5	1948	6.0+	Onions (6)
2b		B					1949	6.0+	Onions (5)
3	Stockbridge.....	B	Carlisle Muck .	5.8	5.7	5.7	1947	6.0+	Corn (6)
4a	Portland.....	B	Carlisle Muck .	5.0	5.8	5.8	1947	5.0+	Mint (5)
4b		B					1946	5.0+	Rye (1)
4c		B					1946 & 1947	5.0+	
5a	Dansville.....	B	Carlisle Muck .	6.4	6.2	6.0	1947 & 1948	5.0+	Mint (6), potatoes (1), mint (1) on part
5b									
5c									
6a	Whitmore Lake.	C	Carlisle Muck .	6.3	6.2	6.4	1945	6.0+	Corn (4), rye green manure (4), manure (2)
6b		C							
7	Jackson.....	C	Carlisle Muck .	5.7	6.0	6.1	1948	4.0+	Onions (4)
8a	East Lansing....	A	Houghton Muck	7.1	6.9	6.5	1949	4.0+	Pasture (4)
8b									
9	Deckerville.....	B	Carlisle Muck .	7.0	5.8	5.8	1947	6.0+	Mint (6)
10	Minden City....	B	Carlisle Muck .	7.3	5.7	5.5	1948	6.0+	Potatoes (1), mint (2), sugar beets (1), rye (1)
11	Imlay City.....	B	Rifle Peat.....	3.8	4.1	4.6	1948	6.0+	Head lettuce (3)
12	Brighton.....	B	Rifle Peat.....	4.3	3.8	4.9	1946	6.0+	Clean cultivation
13	Brown City.....	B	Carlisle Muck .	6.5	4.7	5.1	1947	6.0+	Mint (6)

*Drainage Legend: A—No artificial drainage, B—Open ditches, C—Tiled and ditched.
**ph values determined on samples obtained during the initial time of taking elevations.
***Numbers in parenthesis refer to the frequency of particular crops.

*TABLE 2—Changes in elevations in organic soils**

Site No.	1948 feet	1949 feet	1950 feet	1951 feet	1952 feet	1953 feet	Subsidence, feet
1	100.3 ± .06	100.1 ± .06	100.2 ± .05	100.0 ± .05	——	99.9 ± .04	0.4
2a	99.1 ± .05	99.1 ± .05	98.9 ± .05	98.8 ± .02	——	98.6 ± .02	0.5
2b	——	98.9 ± .04	98.7 ± .03	98.6 ± .02	——	98.2 ± .03	0.7
3	94.6 ± .04	94.2 ± .07	94.1 ± .07	94.4 ± .06	——	94.2 ± .05	0.4
4a	93.3 ± .06	93.1 ± .05	——	——	——	93.0 ± .05	0.3
4b	93.2 ± .03	93.1 ± .04	——	——	——	93.0 ± .01	0.2
4c	93.0 ± .05	92.8 ± .04	——	——	——	92.9 ± .04	0.1
5a	94.6 ± .03	94.5 ± .04	94.4 ± .03	94.3 ± .05	——	94.1 ± .04	0.5
5b	94.6 ± .02	94.4 ± .03	94.6 ± .03	94.6 ± .03	——	94.4 ± .03	0.2
5c	94.6 ± .03	94.3 ± .03	94.6 ± .03	94.6 ± .03	——	94.4 ± .02	0.2
6a	99.5 ± .06	99.5 ± .09	99.5 ± .07	99.6 ± .12	——	99.5 ± .03	0.0
6b	——	99.6 ± .06	99.8 ± .07	99.9 ± .08	——	99.8 ± .02	0.2**
7	——	99.7 ± .03	99.4 ± .03	99.5 ± .03	——	99.4 ± .02	0.3
8a	99.8 ± .12	99.8 ± .10	——	——	——	99.8 ± .13	0.0
8b	——	99.9 ± .10	——	——	——	99.8 ± .07	0.1
9	103.0 ± .04	102.4 ± .06	102.5 ± .07	102.5 ± .04	——	102.5 ± .02	0.5
10	96.5 ± .04	95.9 ± .03	95.8 ± .03	——	——	95.9 ± .03	0.6
11	102.8 ± .03	102.8 ± .03	102.7 ± .02	102.5 ± .03	102.5 ± .03	102.5 ± .02	0.3
12	——	100.0 ± .04	100.1 ± .03	99.9 ± .07	——	99.9 ± .03	0.1
13	99.7 ± .03	99.6 ± .03	99.4 ± .03	99.4 ± .04	——	99.1 ± .03	0.6

*All values significant at the 5% level except for Site 8b.
**This figure indicates 0.2 foot rise in elevation.

occurred. Limitations of control instrumentation and observation made it impossible to evaluate the effect of height of water table upon subsidence. The small amount of data proved insufficient to correlate these factors.

No subsidence was observed in connection with the practice of growing corn with a rye green manure crop annually for four out of six years and 15-20 tons of manure applied per acre for two years at sites 6a and 6b. This is in agreement with laboratory results reported from Ohio (Bingeman, et al., 1953), which indicated no reduction in carbon content of samples to which green organic matter was added.

These data might be interpreted to mean that green-manuring practices are desirable because they tend to reduce wind erosion losses without an accompanying subsidence. At site 2 which showed maximum subsidence, personal observations indicated considerable wind erosion had occurred as evidenced by the nature of the crop damage. Facilities are not presently available to scientifically evaluate the effect of wind erosion on subsidence.

No significant subsidence was noted at the area in continuous pasture (8a and 8b).

Cultivation tended to bring about an increase in the volume weight of the plow-layer (Table 3). If these data (Fig. 2), which are in agreement with observations of Erickson (1949), are considered together with the percentage of moisture at the time of sampling, a negative correlation is obtained. This would indicate that the increased

*TABLE 3—Changes in volume weight after breaking**

Location number**	Year broken	Depth of sample (in.)	Volume weight	Percent Moisture in sample
1	1951	1–4	0.392	160
		13–16	0.278	236
	1918	1–4	0.540	97
		13–16	0.237	334
2	1952	1–4	0.208	218
		13–16	0.193	396
		25–28	0.144	600
	1940	1–4	0.255	274
		13–16	0.159	513

*Date Supplied by R. W. George, Work Unit Conservationist, S. C. S.
**Samples designated as locations 1 and 2 obtained from Site 4 and the Michigan Muck Experiment Farm respectively.

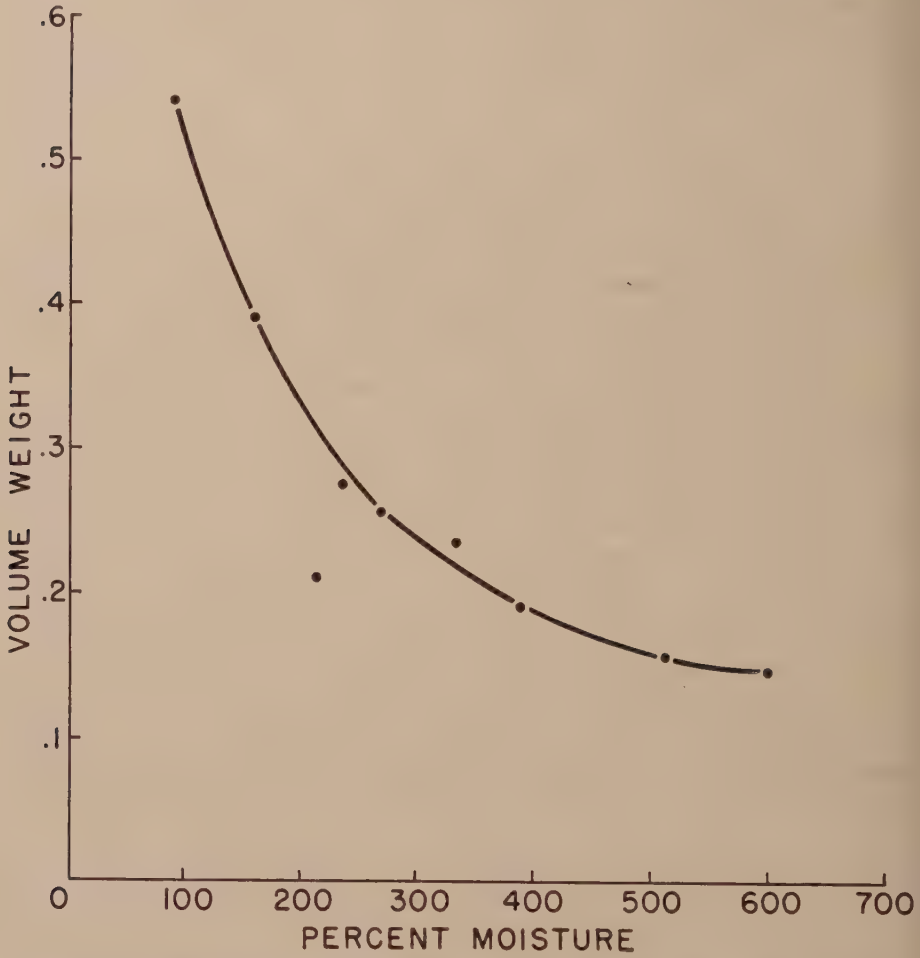

Fig. 2. Relationship between volume weight and percent moisture at time of sampling.

volume weight is in part due to the dehydration of the muck, and that dehydration is one of the causes of subsidence of organic soils in Michigan.

SUMMARY

Changes in surface elevation of three organic soil types, Carlisle Muck, Houghton Muck, and Rifle Peat, at 13 sites in Michigan were studied over a 5-year period. The range of subsidence was found to be 0.0 to 0.7 feet. A triangular compass traverse proved to be a more

satisfactory method of observation than parallel lines of traverse. Profile intervals of 25 feet were found to be as satisfactory for the study as 10 foot intervals.

No correlation between subsidence and soil type was observed within the limits of this study. No subsidence was measured at the site where a green manure crop of rye was grown annually for four out of six years and 15 to 20 tons of manure applied for two years. Data were not sufficient to evaluate the correlation between subsidence and height of water table.

Under cultivation, the volume weight of the plow-layer increased and the percentage of moisture decreased, indicating that dehydration was in part responsible for the subsidence.

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FINANCIAL RATIOS FOR MICHIGAN RURAL ELECTRIC COOPERATIVES[1]

By HO SHENG SUN and H. E. LARZELERE[2]
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PUBLIC INTEREST has been directed toward the rural electric cooperatives as a type of semi-public cooperative organization sponsored by a governmental agency, the Rural Electrification Administration (REA). The ability of these organizations to stand on their own feet after they have passed through their formative period rests largely in the soundness of the business management of each individual concern.

OBJECTIVES OF THIS STUDY

1. To describe several financial ratios and their uses as measuring sticks of the degree of success of Michigan rural electric cooperatives, and to indicate the strong and weak points of a particular organization by comparing it with the group so that more efficient operation may be achieved.

2. To indicate the financial changes of the rural electric cooperatives in Michigan over a period of seven years (1947-53); and

3. To point out the financial problems which Michigan rural electric cooperatives face in the future.

In analyzing the business of rural electric cooperatives, several characteristics that make these organizations different from other types of business should be kept in mind: (1) A large proportion of their initial capital was borrowed from the Rural Electrification Administration, which exercises some management supervision over these organizations. (2) The capital required to operate this kind of business is relatively large as compared with the annual volume of business (oper-

[1]Some of the material in this publication was developed as part of the graduate program of Ho Sheng Sun as partial fulfillment of the requirements for the Ph.D. degree at Michigan State College.

[2]The authors appreciate the advice and assistance given by H. E. Bowen of the Rural Electrification Administration, O. Ulrey of the Agricultural Economics Department, M.S.C., and by the officers and employees of the rural electric cooperatives whose financial reports were used.

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ating revenues). (3) The organizations distribute electric service almost entirely in rural areas. Most other electric distribution companies have a sizable percentage of their service outlets in urban areas.

Financial ratios have been used as guides in various types of business operation. A ratio is a statement of relationship between two quantities or two figures. The use of a ratio frequently will provide a more logical comparison than would comparisons of actual dollars and cents figures. The statistics from which the ratios were derived were obtained from financial statements, chiefly balance sheets and operating statements, of 13 rural electric cooperatives in Michigan.[3]

In order to have a basis for the management of the individual associations to make comparisons, the medians (average) and the highest and lowest values for each ratio have been listed.

FINANCIAL RATIOS AND THEIR TRENDS

An accurate analysis of any individual organization requires an over-all consideration of the combined effects of factors which are related to the business. For the study of the financial ratios, it is quite obvious that no one ratio can tell the whole story. Each organization should examine its own ratios as compared with those of other organizations so that the status of various aspects of the business can be determined.

The following 7 ratios are suggested for the analysis of a rural electric cooperative business:

1. Net margin to operating revenue.
2. Total expenses to operating revenue.
3. Operating revenue to accounts receivable.
4. Operating revenue to total assets.
5. Fixed assets to total assets.
6. Net worth to total assets.
7. Long-term debts to net margin.

NET MARGIN TO OPERATING REVENUE

This ratio shows the amount of net margin the business has made for each dollar of operating revenue (Table 1). A relatively large ratio indicates efficient operations and can be achieved by a reduction in

[3]The total number of rural electric cooperatives in Michigan is 15 (13 of the distribution-type and 2 of the generating-type). The data for the generating-type organizations have not been included in this study since their financial operations would be expected to differ from the distribution-type. The 13 cooperatives averaged about $1,900,000 each in capital investment (total assets) and about $400,000 in annual revenue in 1953.

TABLE 1—Net margin to operating revenue, ratio 1

Year	Lower limit	Median*	Upper limit (most favorable)
1947	−0.19	0.09	0.18
1948	−0.11	0.04	0.10
1949	−0.04	0.09	0.16
1950	−0.03	0.06	0.12
1951	−0.04	0.03	0.13
1952	−0.02	0.05	0.16
1953	−0.08	0.04	0.14

*The median is a middle figure in which half of the organizations have ratio values above the figure and half have values below.

expenses (see ratio 2). The net margin is a residual figure or a remainder after all the expenses have been deducted from the total receipts of the year.

In the rural electric cooperatives, there have been instances in some years where the net margin from operations has been supplemented by gains or losses from the sale of capital assets. Such supplementary items affect the long-run net worth of the organization but do not appear in the net margin to revenue ratio.

Another aspect of interpreting the net margin to operating revenue ratio involves a better understanding of the disposition of the net margin by the members of the organization. The Michigan rural electric cooperatives have not paid a cash patronage refund to their members during the 7 years reported here. Some members of those cooperatives which have shown a substantial net margin have probably wondered why. The answer is that the net margins have been used to make the payments on the principal of the indebtedness, or to invest in additional capital equipment. As a result, the patrons have a capital investment in the business in proportion to their individual shares of the net margin. This situation is not always pointed out clearly enough in the usual financial statements (balance sheet and operating statement).

TOTAL EXPENSES TO OPERATING REVENUE

The total expenses to operating revenue ratio is obtained by dividing the total expenses—which include all the expenses of operation, maintenance, interest, depreciation, etc.—by the operating revenue. Generally speaking, a low ratio means efficient business management.

The ratio of expenses to revenue is probably the most important measure of the operating efficiency of an organization.

Table 2 shows that the total expense ratios ranged from .86 to 1.06 for the Michigan rural electric cooperative during 1953. A ratio of .95, for example, means that there were costs of 95 cents for each dollar of operating revenue. In some cases, the expenses were greater than the operating revenue.

If the management of an organization discovered that a reduction in the percentage of expenses was necessary to bring their operation more in line with other similar organizations, there would need to be further investigation of the component parts of the total expenses. These major subdivisions are cost of power, operation and maintenance expense, interest, depreciation, and other expenses. Table 3 indicates the median values for the various items related to the operating revenue. By comparison the management could determine which of the major categories of expenses needed to be reduced.

For example, a high ratio of cost of power to the operating revenue would suggest inefficient use of facilities. Or it might indicate a need for obtaining power at lower cost. This could be done by negotiating for a cheaper source of power or possibly by erecting generating facilities.

With some organizations it might appear that extending the territory or stimulating greater usage by present customers is the obvious solution to the problem of high expenses to revenue. However, expenses must be checked closely to see that they do not increase out of proportion. Relatively high expenses could neutralize the desirability of increasing revenue.

Organizations with larger revenue did not necessarily have the

TABLE 2—Total expenses to operating revenue, ratio 2

Year	Lower limit (most favorable)	Median	Upper limit
1947	0.82	0.92	1.19
1948	0.92	0.98	1.11
1949	0.87	0.91	1.04
1950	0.88	0.95	1.03
1951	0.86	0.97	1.04
1952	0.84	0.95	1.02
1953	0.86	0.95	1.06

TABLE 3—Median values of cost of power, operation, maintenance, and depreciation per dollar of operating revenue, 1947-53*

Year	Cost of power	Operation and maintenance expense	Interest	Depreciation	Other expenses
1947.....	$0.33	$0.12	$0.11	$0.18	$0.16
1948.....	0.40	0.11	0.10	0.18	0.15
1949.....	0.38	0.10	0.10	0.19	0.14
1950.....	0.39	0.12	0.10	0.19	0.15
1951.....	0.39	0.11	0.09	0.18	0.15
1952.....	0.39	0.11	0.10	0.19	0.16
1953.....	0.42	0.12	0.10	0.19	0.16

*The sum of the 5 columns for each year will not equal the total expense figure given in Table 2, because the median for each type of expense will not necessarily be from the same organization.

lowest expenses to revenue ratio.[4] However, the rural electric cooperative with higher revenue per mile of line consistently had the lowest expenses to revenue ratio.

By examining Figure 1, involving the data for 1953 as an example, it would be possible to determine whether to encourage greater use of electrical energy by present patrons or to extend the territory. In order to cover expenses and provide a reasonable rate of principal repayment, .95 might be considered a maximum desirable ratio of expenses to revenue.

To keep the expense to revenue at .95 or below, it will be desirable that an annual rate of at least $350 of revenue per year per mile of line be obtained. If that rate is not attained from present operations or is not expected in proposed expanded territory, then efforts should be concentrated entirely on increasing revenue and usage within the territory presently served by the lines.

OPERATING REVENUE TO ACCOUNTS RECEIVABLE

This ratio was obtained by dividing the operating revenue by the net amount of accounts receivable (after deducting the reserve for bad debts) at the end of the same year. A higher ratio should be more favorable than a low ratio. In 1953, the median ratio was 8.50, which represented $8.50 in operating revenue for every dollar of net accounts receivable on the book at the end of the year.

In comparison, if the accounts were collected each month the ratio would be 12.0. Therefore, a ratio of 8.50 indicates that more prompt

[4]The coefficient of correlation of revenue to the expenses to revenue ratio was —.17 in 1953 and the coefficient of revenue per mile of line to expenses to revenue ratio was —.93.

payment of customer bills could well be stimulated in many of the organizations. A reduction in the amount of accounts receivable makes capital available for other more productive purposes. If accounts are permitted to go unpaid too long, there is a greater chance that collection will be costly. The company may create bad feeling among the patrons, or collection might become impossible and the account would have to be charged off as a total loss.

TABLE 4—Operating revenue to accounts receivable, ratio 4

Year	Lower limit	Median	Upper limit (most favorable)
1947	1.42	9.59	10.65
1948	6.70	9.48	12.93
1949	0.37	8.61	10.43
1950	2.15	8.35	12.72
1951	2.20	8.32	13.45
1952	2.31	8.76	16.22
1953	4.49	8.50	15.74

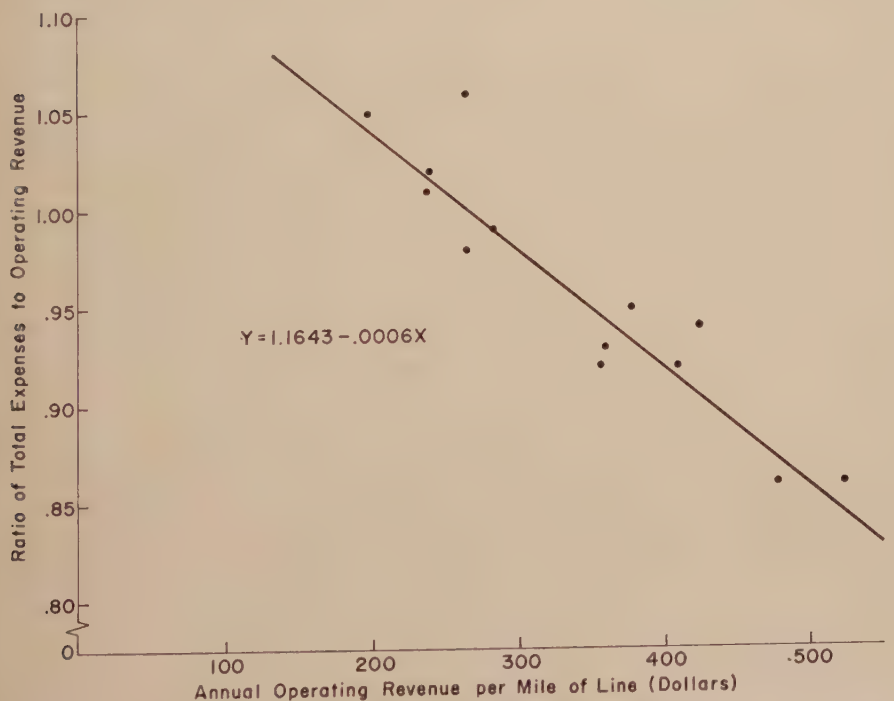

Fig. 1. Relationship of revenue per mile of line to the ratio of total expenses to operating revenue, 1953.

Table 5—Operating revenue to total assets, ratio 5

Year	Lower limit	Median	Upper limit (most favorable)
1947	0.10	0.15	0.18
1948	0.09	0.16	0.21
1949	0.10	0.18	0.25
1950	0.12	0.18	0.27
1951	0.13	0.19	0.30
1952	0.15	0.21	0.35
1953	0.14	0.22	0.39

OPERATING REVENUE TO TOTAL ASSETS

This ratio is obtained by dividing the operating revenue by the total assets. It represents the total amount of operating revenue per dollar of capital investment, and also provides comparable information showing the relationship between the volume of business and the total capital investment of the business. A relatively high ratio is most desirable. In 1953, the Michigan rural electric cooperatives had an average of 22 cents of revenue for every dollar in assets (Table 5).

FIXED ASSETS TO TOTAL ASSETS

This ratio was calculated by dividing the fixed assets, which included the cost of the utility plants and lines less depreciation, by the total assets. This ratio is a measurement of the proportion of the fixed assets to the total capital investment in the business (Table 6).

It would be expected that the annual depreciation charges would tend to reduce this ratio from year to year. This reduction did not

Table 6—Fixed assets to total assets, ratio 6

Year	Lower limit	Median	Upper limit
1947	0.75	0.84	0.93
1948	0.70	0.86	0.91
1949	0.51*	0.84	0.93
1950	0.76	0.86	0.91
1951	0.75	0.84	0.92
1952	0.80	0.86	0.93
1953	0.81	0.89	0.95

*One organization had an exceptionally large amount of current assets (mainly accounts receivable) in that particular year.

take place because each Michigan rural electric cooperative, in order to meet the expanded volume of business and the necessary replacements, increased its net fixed assets by an average of about $100,000 each year during the period of 1947-53.

NET WORTH TO TOTAL ASSETS

This ratio measures to what extent the members of rural electric cooperatives furnish the total capital employed in the business. There was a wide variation in this ratio because of the large differences in the net worth figure of 13 Michigan rural electric cooperatives. The larger the ratio, the better the financial situation should be.

As indicated in Table 7, there seemed to be no appreciable improvement during the 7-year period from 1947 to 1953. Some of the cooperatives had a negative net worth. That meant the association owed a debt greater than the total assets of the business. According to the data available, the average increase in net worth for each cooperative was about $20,000 each year from 1947 through 1953; but the total assets increased proportionately so that the net worth ratios of most of the organizations remained about the same. Since the REA loans remain a vital part of the financial picture of rural electric cooperatives, the objective of complete ownership of these organizations by their member-patrons will not likely be attained in the near future.

LONG-TERM DEBTS TO NET MARGIN

The long-term debt to net margin ratio measures the ability of a cooperative organization to pay back its long-term loans made by REA. In other words, it tells how many years a rural electric cooperative needs to repay its long-term debts out of its annual net margins.

Table 7—Net worth to total assets, ratio 3

Year	Lower limit	Median	Upper limit (most favorable)
1947	−0.12	0.03	0.05
1948	−0.11	0.03	0.14
1949	−0.11	0.02	0.16
1950	−0.08	0.03	0.15
1951	−0.07	0.04	0.23
1952	−0.07	0.03	0.20
1953	−0.08	0.03	0.36

TABLE 8—Long-term debts to net margin, ratio 8

Year	Least favorable	Median	Most favorable
1947	−116.61	70.77	28.94
1948	−272.57	170.44	63.30
1949	−248.06	60.53	27.81
1950	−270.52	95.13	33.55
1951	−135.86	217.33	23.69
1952	−303.54	98.27	21.32
1953	− 68.77	70.25	19.17

In Table 8, the median ratio for 1953 was 70.25, which meant it would take an average of more than 70 years (theoretically) to repay the REA loans out of the average net margins of the cooperatives in 1953. Those cooperatives that had negative margins naturally will have to adjust their operations to a positive net margin if they expect to pay back their loans short of liquidation.

In apparent contrast, most of the rural electric cooperatives in Michigan had met their principal payment promptly. Even though the net margins of the organizations averaged a little over $15,000 per year, each cooperative paid an average of more than $35,000 per year to repay its loan to the REA. This amount was not reflected in any of its financial statements (balance sheet and operating statement).

Where did the money come from? In addition to the net margins, if any, the payment must largely come from the funds represented by the depreciation reserves. These reserves were set aside so the organizations could replace their fixed assets when they are worn out. When the replacement does become necessary, many of the organizations will find that liquid assets, representing the depreciation reserves, have been depleted.

This situation, together with that suggested by Ratio 3 of these organizations, can be interpreted to mean that there should be additional ownership capital in the form of either retained net margins or investment securities or both.

FURTHER ANALYSIS NEEDED

The above analysis of the various ratios has indicated some of the problems for the 13 Michigan rural electric cooperatives as a group. Some of these problems may not apply to an individual organization. However, this information and the method of analysis can be

used by the manager and the board of directors of each individual concern to analyze the financial problems and improve operations.

MONTHLY ANALYSIS

All the information in the above study was derived from the annual data of Michigan rural electric cooperatives. Sometimes, the significance of the analysis was more or less limited due to the monthly variations within the year. For a refinement in management analysis, it may be more desirable to obtain monthly records for the multiple ratio analysis. These ratios will give not only more complete and accurate indications but also will show the month-to-month trend of a particular ratio. This may reveal more quickly the unfavorable aspects of the business than will an annual analysis.

SUMMARY

This financial analysis of the Michigan rural electric cooperatives can be summarized as follows:

1. The use of the several financial ratios will enable the management and members of the individual associations to appraise the operations of their own business from year to year and to compare it with other similar organizations.

2. The ratio of fixed assets to total assets remained about the same during the period of 7 years (1947-53), although the net fixed assets increased by an average of $100,000 each year per organization.

3. The net worth increased about $20,000 per organization each year, but due to proportional increases in total assets, the net worth to total assets ratio remained about the same.

4. Even though the net margins averaged a little over $15,000 per organization, the Michigan rural electric cooperatives were able to repay more than $35,000 in principal payments per organization each year during the period of 1947-53.

5. The apparent use of depreciation reserves for the purpose of principal payments points to a difficult problem when the replacement of fixed assets becomes necessary. This situation would be improved by additional ownership capital through the retaining of savings or the sale of additional securities.

7. A close relationship exists between revenue per mile and the expenses to revenue ratio. Therefore, extension of new lines should not be undertaken unless the proposed additional territory will yield at least $350 of annual revenue per mile.

SEASONAL PURCHASES OF FRESH FRUITS AND VEGETABLES[1]

M.S.C. CONSUMER PANEL 1953

By J. D. SHAFFER and G. G. QUACKENBUSH

THE PURPOSE of this report is to show the relative market position of each of the important fresh fruits and vegetables during each of 13 four-week periods throughout 1953. It indicates the variations in the competitive relationships between the fresh fruits and vegetables during the different seasons of the year.

Like most market reports, the information may be useful to a number of different groups for different purposes. However, it should be of special value to merchandisers of produce in planning their margins, promotions and display allocations. These figures should also be helpful to retailers who recognize the importance of handling a wide variety of produce items, but have wondered what number might be a reasonable minimum. Similarly, a knowledge of the relative share of the market and percent of families buying should prove helpful to those interested in marketing or promoting a particular product. Those charged with responsibilities for providing information to consumers should likewise find the information useful.

UNIQUENESS OF DATA

The data for this report are unique. They are based upon reports from the only existing project getting continuous information at the consumer level for all the fresh fruits and vegetables. Estimates of the percent of families buying can only be obtained from consumer surveys.

[1]Based upon reports from the families of the M.S.C. Consumer Panel during 1953. For a discussion of the general sampling procedure followed for the M.S.C. Consumer Panel, see J. D. Shaffer (Feb. 1954). "A Plan For Sampling A Changing Population Over Time." *Jour. of Farm Econ.* 30: pp. 153-163. For a discussion of the nature of panel data and its use in demand analysis see C. G. Quackenbush (Aug. 1954). "Demand Analysis From M.S.C. Consumer Panel Data." *Jour. of Farm Econ.* 36: pp. 415-427.

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While many other consumer surveys are and have been made dealing with consumer purchases on a one-time or recall basis, they have not been able to estimate the seasonal variations. There are other consumer panels, but none receive reports on all fresh fruits and vegetables.

There are few sources of information on these products which provide data from all sources of supply, with actual expenditures by consumers. The records of a single store or even all grocery stores do not provide a picture of the complete market.

On the other hand, the data have limitations. They are gathered from a limited locality. It is believed that they are fairly representative of urban Michigan and similar areas, but, of course, are not applicable to all localities. They represent only one year in time, 1953. The variation between years is not known. As the project continues and several years data are available, more complete reports can be made.

NATURE OF REPORT

This report consists essentially of 13 tables, one for each of the 13 four-week periods of 1953. Each of these 13 tables lists the 25 fresh fruits and vegetables for which panel members spent the most money. The products are listed or ranked in order of the expenditures from high to low.

The percent of the consumers' fresh fruit and vegetable dollar spent for each of the products is also given. For example, Table 2 indicates that about 18 cents out of every dollar spent for fresh fruits and vegetables during the first four-week period was spent for potatoes.

In each period, expenditures for the 25 products accounted for 94 percent or more of the total expenditures for fresh fruits and vegetables.

Other important market data are the number or percent of the families buying a product. The panel reports were tabulated each week to determine the percent of families buying particular products. The right hand column of each table summarizes these weekly figures by giving the average percent of families buying a product per week during a four-week period.[2]

This report is limited to a presentation of data on expenditures and percent of families buying during different time periods. The

[2]Additional families may have received the product as a gift or may have taken them from home grown stock.

major emphasis has been upon the time period rather than on the individual products. Additional reports will be made with emphasis on the individual product and will include price and quantity data.

SEASONAL DIFFERENCES

It is believed that the tables are largely self-explanatory and that it would be superfluous to discuss them individually. A few comments on the seasonal differences and highlights may nevertheless be appropriate.

The M.S.C. Consumer Panel families spent about $51 per person for all fruits and vegetables, fresh and processed, consumed at home during 1953. The expenditure was divided almost equally between fruits and vegetables. Fresh fruits and vegetables—as contrasted with frozen, canned and dried—made up slightly more than half the total expenditures, amounting to about $26.50 per person.

The seasonal variation in expenditures for fresh fruits and vege-

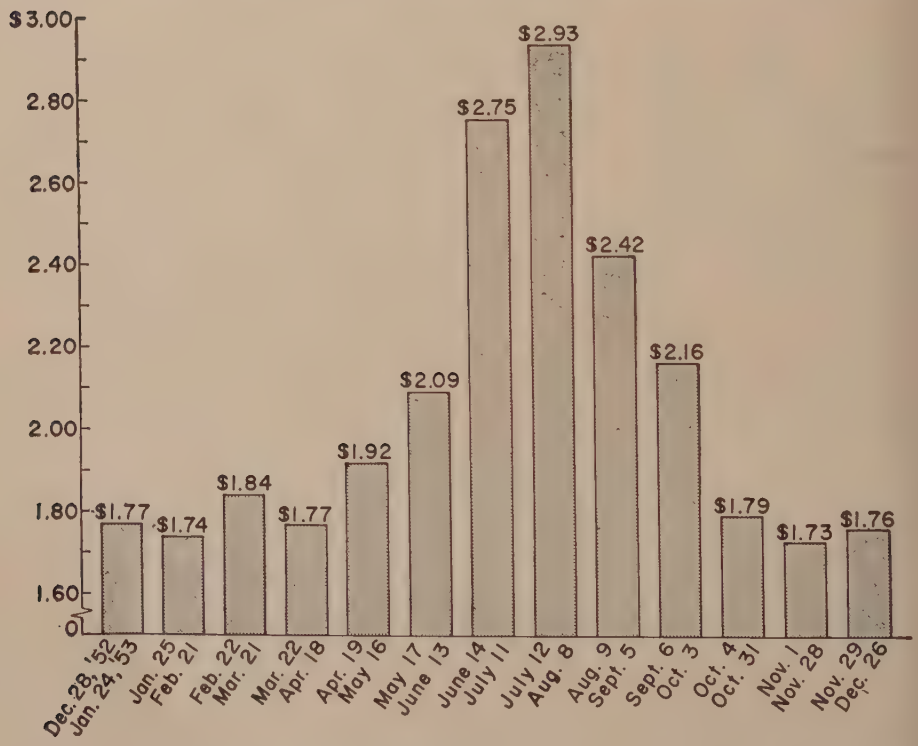

Fig. 1. Seasonal variation in expenditures per person for fresh fruits and vegetables, M.S.C. Consumer Panel, 1953.

tables is shown in Figure 1. Note that expenditures during the peak period, July 12 - August 8, were about 70 percent higher than during the lowest period, November 1 - November 29.

THE TOP TEN

Ten products made up from 68 to 84 percent of the total expenditures for fresh fruits and vegetables in each of the 13 periods. (The percent for each period is shown on each of the tables.) But they were not the same products every period. The ten top products for the year accounted for two-thirds of all expenditures for fresh fruits and vegetables. (Table 15.)

Only four of these products, potatoes, bananas, head lettuce and oranges were among the top 10 every period. Twenty-two different products were among the top 10 during one or more periods. Table 1 shows the periods each of these were among the top 10 and its expenditure rank.

PERCENT OF FAMILIES BUYING

Head lettuce and bananas appear in the average homemaker's shopping bag more frequently than any other fresh fruits or vegetables. During an average week in 1953, 48 percent of the families reported buying head lettuce and 46 percent reported buying bananas. These two products were consistently high. Head lettuce ranked first in terms of percent of families buying during eight periods and bananas during four periods. Peaches were first during one period.

Potatoes, apples, oranges, celery and carrots each averaged over 20 percent of the families buying each week for the year. The percent buying is shown for each product for each period and for the year in Tables 2 - 15.

TABLE 1—Expenditure rank and period when twenty-two fresh fruits and vegetables were among the top ten

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	T
Fruit or Vegetables	Dec. 28, '52— Jan. 24, '53	Jan. 25— Feb. 21	Feb. 22— March 21	March 22— April 18	April 19— May 16	May 17— June 13	June 14— July 11	July 12— Aug. 8	Aug. 9— Sept. 5	Sept. 6— Oct. 3	Oct. 4— Oct. 31	Nov. 1— Nov. 28	Nov. 29— Dec. 26	1953
Potatoes	1	1	1	2	2	1	2	2	2	4	2	3	3	1
Bananas	2	2	2	1	1	2	3	3	4	3	3	1	1	2
Apples	3	4	3	5	5	8			8	2	1	2	2	3
Head Lettuce	5	6	5	4	4	4	6	7	6	6	4	4	5	4
Oranges	4	3	4	3	3	5	8	10	9	9	5	5	4	5
Tomatoes		10	9	8	6	6	5	4	5	5				6
Celery	7	7	7	7	8	7	9				6	6	7	7
Grapefruit	6	5	6	6	7						9	7	6	8
Carrots	8	8	8	9	9	9					8	8	9	9
Strawberries						3	1							10
Peaches									1	1				
Muskmelon, etc.							4	5	3	7				
Mature Onions	10	9	10	10							10			
Raspberries							10	1						
Watermelon						10	7	9						
Grapes										8	7	9	10	
Sweet Corn								6	7					
Tangerines	9													
Asparagus					10									
Blueberries									10					
Pears										10				
Cranberries												10		

TABLE 2—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, December 28, 1952-January 24, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Potatoes	18.4%	34%
2	Bananas	13.0	46
3	Apples	10.8	29
4	Oranges	8.7	27
5	Head lettuce	7.9	48
6	Grapefruit	6.3	20
7	Celery	4.9	26
8	Carrots	4.4	30
9	Tangerines	3.2	13
10	Mature onions	3.1	18
	Top Ten	80.7%	
11	Cabbage	2.8	22
12	Tomatoes	2.8	11
13	Grapes	1.6	7
14	Lemons	.9	7
15	Broccoli	.9	4
16	Sweet potatoes and yams	.8	3
17	Spinach	.8	4
18	Peppers	.8	7
19	Radishes	.7	6
20	Turnips and rutabagas	.7	5
21	Cranberries	.6	2
22	Parsnips	.5	3
23	Cauliflower	.5	2
24	Brussel Sprouts	.4	2
25	Squash	.4	3
	All others	4.1	

TABLE 3—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, January 25-February 21, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Potatoes	17.2%	32%
2	Bananas	13.5	44
3	Oranges	10.4	31
4	Apples	9.9	26
5	Grapefruit	9.4	29
6	Head lettuce	7.6	47
7	Celery	4.8	28
8	Carrots	4.5	31
9	Mature onions	3.4	18
10	Tomatoes	2.9	12
	Top Ten	83.6%	
11	Cabbage	2.4	22
12	Tangerines	1.2	6
13	Lemons	1.0	8
14	Broccoli	1.0	5
15	Grapes	1.0	5
16	Spinach	.8	4
17	Peppers	.8	8
18	Radishes	.8	7
19	Cauliflower	.7	3
20	Turnips and rutabagas	.5	5
21	Cucumber	.4	3
22	Parsnips	.4	3
23	Sweet potatoes and yams	.4	2
24	Green onions	.4	3
25	Avocados	.3	2
	All others	4.3	

TABLE 4—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, February 22-March 21, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Potatoes	14.5%	34%
2	Bananas	14.3	50
3	Apples	12.5	32
4	Oranges	10.1	34
5	Head lettuce	8.3	51
6	Grapefruit	8.0	26
7	Celery	4.4	27
8	Carrots	4.2	32
9	Tomatoes	3.3	14
10	Mature onions	2.9	16
	Top Ten	82.5%	
11	Cabbage	2.4	20
12	Spinach	1.1	6
13	Radishes	1.1	10
14	Peppers	.9	9
15	Lemons	.9	7
16	Cucumbers	.8	6
17	Grapes	.7	3
18	Broccoli	.6	3
19	Pineapple	.6	1
20	Snap beans	.6	2
21	Turnips and rutabagas	.5	4
22	Sweet potatoes and yams	.5	2
23	Asparagus	.5	2
24	Cauliflower	.5	2
25	Green onions	.4	4
	All others	5.4	

TABLE 5—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, March 22-April 18, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Bananas	16.5%	54%
2	Potatoes	14.3	36
3	Oranges	10.1	33
4	Head lettuce	8.5	54
5	Apples	8.1	22
6	Grapefruit	7.1	24
7	Celery	4.8	25
8	Tomatoes	4.1	18
9	Carrots	4.1	31
10	Mature onions	3.3	18
	Top Ten	80.9%	
11	Asparagus	2.6	11
12	Cabbage	2.4	20
13	Cucumbers	1.5	11
14	Radishes	1.4	11
15	Peppers	1.0	9
16	Lemons	.9	7
17	Sweet potatoes and yams	.9	3
18	Green onions	.8	7
19	Pineapple	.7	3
20	Spinach	.7	3
21	Strawberries	.6	2
22	Broccoli	.5	2
23	Cauliflower	.5	2
24	Leaf lettuce	.4	3
25	Turnips and rutabagas	.3	3
	All others	3.9	

TABLE 6—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, April 19-May 16, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Bananas	15.7%	56%
2	Potatoes	13.4	37
3	Oranges	9.8	34
4	Head lettuce	9.0	56
5	Apples	7.5	21
6	Tomatoes	5.8	24
7	Grapefruit	5.1	18
8	Celery	4.7	24
9	Carrots	3.7	29
10	Asparagus	3.6	15
	Top Ten	78.3%	
11	Mature onions	2.4	17
12	Strawberries	2.2	6
13	Cabbage	2.2	18
14	Cucumbers	2.0	15
15	Radishes	1.6	13
16	Lemons	1.4	9
17	Green onions	.9	9
18	Pineapple	.9	3
19	Peppers	.8	9
20	Spinach	.8	5
21	Rhubarb	.4	2
22	Snap beans	.4	1
23	Watermelon	.4	1
24	Broccoli	.4	2
25	Leaf lettuce	.3	3
	All others	4.6	

TABLE 7—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, May 17-June 13, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Potatoes	14.2%	43%
2	Bananas	14.1	55
3	Strawberries	10.5	24
4	Head lettuce	7.5	48
5	Oranges	7.1	26
6	Tomatoes	7.1	30
7	Celery	5.0	26
8	Apples	3.8	13
9	Carrots	3.7	31
10	Watermelon	3.1	7
	Top Ten	77.5%	
11	Asparagus	2.8	16
12	Grapefruit	2.4	10
13	Radishes	2.4	29
14	Mature onions	2.3	17
15	Muskmelon and cantaloupe	2.2	7
16	Lemons	1.8	12
17	Cucumbers	1.8	14
18	Cabbage	1.6	17
19	Green onions	1.1	12
20	Peppers	.9	10
21	Pineapple	.7	3
22	Spinach	.6	4
23	Rhubarb	.5	3
24	Broccoli	.4	2
25	Leaf lettuce	.3	3
	All others	2.1	

TABLE 8—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, June 14-July 11, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Strawberries	19.4%	36%
2	Potatoes	9.8	42
3	Bananas	8.7	43
4	Muskmelon and cantaloupe	6.6	31
5	Tomatoes	6.4	28
6	Head lettuce	6.4	54
7	Watermelon	5.2	14
8	Oranges	4.7	21
9	Celery	3.8	26
10	Raspberries	3.1	7
	Top Ten	74.1%	
11	Lemons	2.7	18
12	Cucumbers	2.2	22
13	Carrots	2.1	24
14	Mature onions	1.8	18
15	Sweet cherries	1.6	4
16	Cabbage	1.6	17
17	Radishes	1.5	24
18	Green onions	1.2	15
19	Peaches	1.2	6
20	Sour cherries	1.1	2
21	Grapefruit	.9	6
22	Apples	.8	4
23	Peppers	.7	11
24	Plums	.7	4
25	Asparagus	.6	4
	All others	5.2	

TABLE 9—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, July 12-August 8, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Raspberries	17.3%	24%
2	Potatoes	8.4	38
3	Bananas	7.9	43
4	Tomatoes	6.8	35
5	Muskmelon and cantaloupe	5.5	29
6	Sweet corn	5.2	28
7	Head lettuce	5.1	42
8	Peaches	4.6	26
9	Watermelon	3.8	11
10	Oranges	3.5	18
	Top Ten	68.1%	
11	Blueberries	2.9	10
12	Celery	2.8	24
13	Sweet cherries	2.4	6
14	Lemons	2.3	17
15	Cucumbers	2.1	21
16	Carrots	2.0	23
17	Sour cherries	1.9	3
18	Apples	1.9	10
19	Mature onions	1.6	18
20	Snap beans	1.5	10
21	Cabbage	1.2	18
22	Radishes	1.1	17
23	Green onions	1.0	12
24	Plums	.8	4
25	Peppers	.7	10
	All others	5.7	

TABLE 10—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, August 9-September 5, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Peaches	14.4%	42%
2	Potatoes	9.7	37
3	Muskmelon and cantaloupe	9.6	37
4	Bananas	7.3	33
5	Tomatoes	7.3	29
6	Head lettuce	5.8	40
7	Sweet corn	5.6	27
8	Apples	4.5	20
9	Oranges	3.5	15
10	Blueberries	3.2	11
	Top Ten	70.9%	
11	Watermelon	3.0	9
12	Celery	2.8	22
13	Cucumbers	2.4	13
14	Pears	2.2	6
15	Mature onions	2.1	14
16	Lemons	2.0	13
17	Grapes	1.8	9
18	Carrots	1.8	18
19	Peppers	1.3	12
20	Cabbage	1.2	16
21	Snap beans	1.1	7
22	Plums	.8	4
23	Radishes	.7	9
24	Green onions	.6	7
25	Squash	.6	6
	All others	4.7	

TABLE 11—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, September 6-October 3, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Peaches	11.5%	25%
2	Apples	11.4	34
3	Bananas	10.8	42
4	Potatoes	10.2	34
5	Tomatoes	6.1	18
6	Head lettuce	5.8	40
7	Muskmelon and cantaloupe	5.3	21
8	Grapes	3.8	9
9	Oranges	3.5	14
10	Pears	3.3	8
	Top Ten	71.7%	
11	Celery	3.1	22
12	Carrots	2.5	20
13	Plums	2.4	6
14	Mature onions	2.4	18
15	Cauliflower	2.3	15
16	Squash	1.7	12
17	Cabbage	1.3	14
18	Cucumbers	1.1	7
19	Sweet potatoes and yams	1.0	6
20	Sweet corn	1.0	6
21	Peppers	.9	9
22	Lemons	.8	6
23	Watermelon	.8	3
24	Blueberries	.7	2
25	Snap beans	.7	4
	All others	5.6	

TABLE 12—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, October 4-October 31, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Apples	17.4%	35%
2	Potatoes	16.6	31
3	Bananas	14.3	46
4	Head lettuce	7.9	45
5	Oranges	6.5	21
6	Celery	3.9	23
7	Grapes	3.7	17
8	Carrots	3.6	25
9	Grapefruit	3.0	12
10	Mature onions	2.2	15
	Top Ten	79.2	
11	Cauliflower	2.1	13
12	Squash	1.9	10
13	Tomatoes	1.8	9
14	Cabbage	1.5	15
15	Sweet potatoes and yams	1.5	7
16	Cranberries	1.2	6
17	Pears	.9	2
18	Radishes	.7	6
19	Peppers	.7	6
20	Muskmelon and cantaloupe	.6	2
21	Turnips and rutabagas	.6	5
22	Cucumbers	.5	4
23	Parsnips	.5	3
24	Spinach	.5	3
25	Brussel sprouts	.5	2
	All others	5.3	

TABLE 13—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, November 1-November 28, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Bananas	14.4%	44%
2	Apples	13.5	29
3	Potatoes	10.6	27
4	Head lettuce	9.0	49
5	Oranges	8.4	25
6	Celery	5.4	29
7	Grapefruit	5.1	19
8	Carrots	4.0	25
9	Grapes	2.7	12
10	Cranberries	2.4	12
	Top Ten	75.5%	
11	Mature onions	2.4	15
12	Tomatoes	2.2	9
13	Squash	2.2	10
14	Sweet potatoes and yams	1.9	8
15	Cabbage	1.8	15
16	Tangerines	1.8	9
17	Peppers	1.1	9
18	Cauliflower	.8	4
19	Cucumbers	.8	5
20	Radishes	.8	7
21	Spinach	.8	4
22	Lemons	.8	5
23	Turnips and rutabagas	.7	5
24	Pears	.6	2
25	Brussel sprouts	.5	2
	All others	3.3	

TABLE 14—Competitive relationship between the 25 top fresh fruits and vegetables, M.S.C. Consumer Panel, November 29-December 26, 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Bananas	14.0%	44%
2	Apples	13.3	30
3	Potatoes	10.7	28
4	Oranges	10.4	30
5	Head lettuce	8.2	49
6	Grapefruit	5.8	21
7	Celery	5.5	30
8	Tangerines	4.9	18
9	Carrots	4.1	25
10	Grapes	2.5	10
	Top Ten	79.4%	
11	Cranberries	2.1	11
12	Cabbage	1.8	15
13	Tomatoes	1.8	6
14	Mature onions	1.7	10
15	Sweet potatoes and yams	1.6	7
16	Peppers	.9	7
17	Squash	.9	5
18	Radishes	.9	7
19	Cucumbers	.8	7
20	Lemons	.8	6
21	Spinach	.7	3
22	Turnips and rutabagas	.6	5
23	Brussels sprouts	.5	2
24	Snap beans	.4	2
25	Green onions	.4	2
	All others	4.7	

TABLE 15—Competitive relationship between the 50 top fresh fruits and vegetables, M.S.C. Consumer Panel, year of 1953

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
1	Potatoes	13.1%	35%
2	Bananas	12.2	46
3	Apples	8.1	24
4	Head lettuce	7.3	48
5	Oranges	7.0	25
6	Tomatoes	4.8	18
7	Celery	4.2	26
8	Grapefruit	3.8	15
9	Carrots	3.3	26
10	Strawberries	3.1	5
	Top Ten	66.9%	
11	Peaches	2.9	8
12	Muskmelon and cantaloupe	2.8	10
13	Mature onions	2.4	16
14	Raspberries	2.2	2
15	Cabbage	1.8	18
16	Watermelon	1.6	3
17	Grapes	1.4	7
18	Cucumbers	1.4	10
19	Lemons	1.4	9
20	Sweet corn	1.2	5
21	Radishes	1.1	12
22	Peppers	.9	9
23	Tangerines	.7	3
24	Asparagus	.7	4
25	Blueberries	.7	2
26	Squash	.7	5
27	Green onions	.7	6
28	Pears	.6	2
29	Sweet potatoes and yams	.6	3
30	Cauliflower	.6	4

TABLE 15—Competitive relationship between the 50 top fresh fruits and vegetables, M.S.C. Consumer Panel, year of 1953 (con't.)

Expenditure Rank	Product	Percent of total fresh fruit and vegetable expenditure	Average percent of families buying each week
31	Snap beans	.6%	3%
32	Spinach	.5	3
33	Cranberries	.5	3
34	Plums	.5	2
35	Sweet cherries	.4	1
36	Broccoli	.4	2
37	Sour cherries	.3	*
38	Turnips and rutabagas	.3	3
39	Leaf lettuce	.3	2
40	Pineapple	.2	1
41	Parsnips	.2	2
42	Brussel sprouts	.2	1
43	Avocados	.2	1
44	Celery cabbage	.1	1
45	Beets	.1	1
46	Rhubarb	.1	1
47	Peas	.1	1
48	Egg plant	.1	1
49	Apricots	.1	*
50	Limes	.1	*

*Less than .5 percent.

A LINEAR PROGRAMMING ANALYSIS OF BEEF CATTLE FEEDING[1]

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LINEAR PROGRAMMING enables us to compute the maximum profit obtainable from limited quantities of resources where a given set of production processes is available. It is designed specifically for production processes in which the proportions of the cooperating inputs cannot be altered, but it is a useful computational device even in agriculture, where this assumption is not often fulfilled.

LINEAR PROGRAMMING EXPLAINED

Linear programming consists essentially of establishing a physical budget for each enterprise available, calculating the amount of each limited factor which a unit of each enterprise requires, and then discovering (by a systematic trial and error process) which of the many practicable combinations of enterprises will return the most net revenue.

Because the method is systematic, there is no chance that some profitable combinations of the given set of ventures will be accidentally overlooked. Since the calculations do not require guesses about the value of fixed factors, their accuracy will not be thrown off by the use of artificial prices for this purpose. When the best combination has been discovered, the programming calculations provide a valuation of each of the limited factors.

Moreover, the influence of relative prices may be stated explicitly, and the influence of limitations on the quantities of factors available may be separated from the influence of the relative prices of non-limited factors.

SELECTING BEEF FEEDING PROGRAM

Let's analyze the problem of selecting the most profitable beef-feeding program for a 250-acre central Michigan farm with 60 acres

[1]The author is heavily indebted to Professor Lauren H. Brown, who not only suggested the problem and the characteristics of the farm to be studied, but was also his guide to sources of data.

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of pasture and an annual production of 80 tons of good alfalfa hay. Assume that the farmer does not chose to use his hay and pasture for any other enterprise. He has 418 hours of labor available in the summer months (April through October) and 906 hours available in the winter months. His buildings provide 3,500 square feet of shelter, with enough space for storing the hay and feed needed by any animals he can house.

In the form of cash plus corn[2] he has $4,700 that he is willing to devote to beef cattle feeding, and he is willing and able to borrow $7,500 more for this purpose. His stock of available funds is thus $12,200. He is also able to borrow whatever extra funds may be required for carrying one feeding program to completion simultaneously with starting a new lot of animals the following fall (in case a feeding system that takes more than one year turns out to be the most profitable).

These quantities of hay, pasture, summer labor, winter labor, shelter and funds set the limits within which he must operate. Let's assume that no alternative uses other than steer feeding are available for these inputs and that, during the period of time for which we are planning, no increases in the limited quantities are possible or practicable.[3] The problem is to maximize the return obtainable from this set of limited factors. Markets are perfect for corn and all other inputs or outputs.

ADAPTING FEEDING PROGRAM

Let's adapt the feeding program to these limits. The possibilities of substitution among these inputs are represented by considering as alternative processes seven beef cattle feeding systems, chosen so as to require different proportions of hay, grain, etc.[4]

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[2]In this problem we do not need to distinguish corn from cash, but to fix the ideas, let us say 2,140 bushels of No. 2 yellow corn, at $1.49 per bushel, and the remainder in cash.

[3]The existence of alternative uses and of the possibility of increasing the quantities of some of these factors may be taken into account, as we shall show later.

[4]Process 1: Calves—Begin October 15, at 450 pounds. About 50 days on aftermath pasture and/or cornstalks. Dry lot fattening on full feed until July 31. Market at 1,000 pounds.

Process 2: Calves—Begin October 15, at 450 pounds. About 50 days on aftermath pasture and/or cornstalks. Winter on good quality legume hay. Turn out on pasture May 1, and during first three weeks get up to full grain feeding along with pasture. Market September 15, at 935 pounds.

Process 3: Calves—Begin October 15, at 450 pounds. About 50 days on aftermath pasture and/or cornstalks. Winter on good quality legume hay. Turn out on pasture May 1. Start feeding grain on pasture July 15. October 1 start dry lot feeding. Market November 15, at 1,050 pounds.

Process 4: Calves—Same as Processes 2 and 3 until May 1. Then pasture with no grain until August 29, when shift to full grain feeding in dry lot. Market December 6, at 1,050 pounds.

Process 5: Yearlings—Begin October 15, at 775 pounds. Thirty days on aftermath pasture and/or cornstalks; then full grain feeding in dry lot until April 15. Market at 1,175 pounds.

Process 6: Yearlings—Begin October 15, at 600 pounds. About 50 days on aftermath pasture and/or cornstalks. Winter on hay and limited amount of grain until May 15, then turn into pasture. No grain until July 1, when begin full grain feeding on pasture. Market November 1, at 1,160 pounds.

Process 7: Two-year-olds or older—Begin October 15, at 850 pounds. Thirty days on aftermath pasture and/or cornstalks. Then move to dry lot and full grain feeding. Market February 15, at 1,125 pounds.

TABLE 1—Data for each process. Unit: 1 animal, assuming no death loss[1]

Feeding system (process)		Inputs									Output	Prices that vary with the process		Other
		Starting weight (pounds)	Corn and cob meal (pounds)	Protein supplement (pounds)	Hay (pounds)	Spring and summer pasture (acres)[2]	Summer labor (hours)[3]	Winter labor (hours)[3]	Shelter (square feet)[4]	Elapsed time (months)[5]	Finished weight (pounds)	Feeder stock (dollars per hundred pounds)[6]	Finished steer (dollars per hundred pounds)[7]	Price[8]
Calves	1	450	2,880[9]	420	1,560	0	6.5	6.5	30	9.5	1,000	24.88	29.00	
	2	450	1,960	60	2,520	.31	6.5	3.5	30	11.0	935	24.88	28.42	Corn:
	3	450	1,935	143	2,880	.73	7.0	4.0	30	13.0	1,050	24.88	27.29	$1.49 per bushel
	4	450	1,500	200	3,120	1.00	6.0	5.5	30	13.7	1,050	24.88	26.93	
Yearlings	5	775	2,175	300	1,050	0	.5	9.0	45	6.0	1,175	23.76	27.24	Protein supplement:
	6	600	2,900	200	2,400	1.24	7.5	3.0	40	12.5	1,160	23.76	27.05	$85.00 per ton
Two-year olds	7	850	1,400	143	760	0	.2	6.0	50	4.0	1,125[10]	23.28	27.01	Interest rate: 5% per year

Footnotes for Table 1

[1] Except for Process 6, data on weights, feed consumption and duration of process are from Departments of Animal Husbandry and Agronomy, Purdue University, "A Comparison of Different Systems of Feeding Beef Cattle with Special Emphasis on Utilization of Hay and Pasture", Memo No. 666-31, January, 1948, pp. 5-9, 14, 15. Process 6 data from Dr. Lauren H. Brown, after checking with Animal Husbandry Department, Michigan State College.

[2] The Purdue estimate of pasture requirements (Ibid, p. 15) was raised by ⅓ to allow for the shorter season in Michigan. We assume that the acreage requirements stated take into account the varying lengths of time the pasture will be used.

Obviously pastures of different quality have different carrying capacity. Our results may be made applicable to pastures of different capacity than that assumed here by considering the 60 acres of pasture available on the farm we are studying as the equivalent of 120 acres of pasture with half the capacity, and so forth.

[3] Labor requirement data are based on estimates furnished by Dr. Brown. The allocation between summer and winter labor is affected by the exact date on which one shifts from one phase of the feeding operation to another, and this date will be variable, depending upon the weather, the condition of the pasture, etc. Since the Purdue outline was not very precise in its estimate of time periods, minor inconsistencies have crept into our allocation of labor between the winter and summer months. However, the very nature of the labor estimates is such that we could hardly expect figures on requirements per animal to be accurate to less than the half hour, except for Process 7, which requires some summer labor, but clearly less than a half hour per animal. In fact, labor requirements per animal are not independent of the size of the lot of animals handled. (This is probably the only input for which non-linearity is a serious problem.) Our estimates assume that the animals are handled in car-load lots: about 40 calves, 35 yearlings, or 30 two-year-olds. Our final solution requires examination to ascertain whether the assumption of constant labor requirements per animal has introduced any serious error.

[4] Estimates of space requirements made by Dr. Brown.

[5] In view of the difficulty with dates referred to in footnote [3], these figures must be regarded as somewhat approximate. They are used in the calculation of interest charges and in determining marketing dates, and thus the price received for the finished animal. The significant error, if any, is probably in the latter category.

Footnotes for Table 1 (con't.)

[6] Yearling and two-year-old prices are October seasonal prices, adjusted for price level and trend, of choice stocker and feeder steers at Kansas City, 1938-50, in 1947-9 dollars. (Cox, C. B., Eisenach, E. J., and Mitchell, M. P., "Beef Cattle Prices," Purdue University, Agricultural Experiment Station Bulletin 582, January, 1953, p. 32.) We used the 500-800 pound class price for our yearlings and the 800-1000 pound class price for our two-year-olds. Miller reports a spread of $1.12 between 650 pound good and choice yearlings and 420 pound good and choice calves in the average September-November price at Kansas City, from 1946-7 to 1951-2. (Miller, Earle E., "Profits from 4 Different Cattle Feeding Programs," *The Livestock and Meat Situation*, November-December, 1952, pp. 19, 20.) The spread between yearlings and heavy animals (good grade) in his data was 39 cents; the spread between yearlings and two-year-olds in the data used above is 48 cents for choice steers. Since the spreads were similar and the levels of prices comparable, we added Miller's $1.12 to our price for yearlings to get a price for calves.

[7] Seasonal prices (adjusted for price level and trend) of choice slaughter steers in Chicago, 1939-50, in 1947-9 dollars, from Cox, Eisenbach, and Mitchell, *Op. cit.*, p. 20. When our marketing date was not the middle of he month, we used straight line interpolation.

[8] *Agricultural Prices* for May 29, 1953, gave the price of corn per bushel on May 15 as $1.49. We have assumed that soybean meal at $85 per ton will be our protein supplement and have assumed a 5 percent rate of interest.

[9] We used the larger of two figures on corn consumption. (In other systems, a single figure was given.)

[10] This is the mean of the end weight figures given in Purdue Memo. No. 666-31.

Six of these systems are drawn from those suggested by the Departments of Animal Husbandry and Agronomy at Purdue University.[5] Process 6 was prepared by Dr. Lauren H. Brown of the Agricultural Economics Department at Michigan State College. For computational purposes, we have neglected the range of variation in dates and weights which actually occurs in good practice. Each system or process, as stated here, represents what might be considered a typical sequence. The experienced herdsman should have little difficulty in making allowances for the excessive precision with which our processes are described.

Table 1 contains the technological and price data for each process. The feeder cattle prices used for yearlings and two-year olds are average October seasonal prices of choice stocker and feeder steers at Kansas City, from 1938 to 1950, expressed in 1947-9 dollars.[6] The price for calves was obtained by adding $1.12, the spread found by Earle Miller,[7] to the price of yearlings. Finished steer prices are average seasonal prices of choice slaughter steers in Chicago from 1939 to 1950, in 1947-9 dollars.[8]

Having prepared physical budgets for each process, calculate the net revenue obtainable from each system of feeding. From the value of the finished steers must be subtracted the cost of the feeder animals,

[5] "A Comparison of Different Systems of Feeding Beef Cattle with Special Emphasis on Utilization of Hay and Pasture," Memo. No. 666-31, January, 1948, pp. 5-9. (Prepared cooperatively by Purdue University Agricultural Experiment Station, Lafayette, Indiana, and Soil Conservation Service, Region III, U. S. Department of Agriculture.)

[6] Cox, C. B., E. J. Eisenach and M. P. Mitchell (1953). Beef cattle prices, Purdue University, Agr. Expt. Sta. Bul. 582, p. 32.

[7] Miller, Earle E., Profits from 4 different cattle feeding programs. The Livestock and Meat Situation, November-December, 1952: 19-20.

[8] Cox, Eisenach, and Mitchell, op. cit., p. 20.

corn, and protein supplement, plus the interest charge.[9] In order to allow for a 2 percent death loss assume that we buy 102 animals and sell 100.

For the purpose of computing the net revenue from each process, corn and supplement requirements for the lot of animals are computed on the assumption that two die upon making half their gain. Charge interest (at 5 percent) on the cost of the feeder animals, but not on the value of the corn or supplement required.[10]

CHOOSING FEEDING SYSTEMS

We must now choose from among the feeding systems available in such a way as to maximize the net revenue obtainable from our limited factors. We cannot simply choose the process which yields the largest net revenue per lot of 102 animals purchased, for we may not be able to handle as many animals on that system as on some other one.

Process 4 yields the maximum net revenue per lot ($12,162), but

[10]There may be some realism in the assumption that the farmer will consider interest as a cost only in the case of funds invested in feeder stock. In our case, this practice is equivalent to assuming the farmer's opportunities for profitable alternative uses of his funds are limited to the funds he can invest in feeder stock, in addition to the $7,500 borrowed for stock purchases. Should borrowed funds not be entirely spent for feeder stock our treatment would fail to charge the whole of the bank payment against gross revenue. This difficulty did not arise in our problem. Probably it would have been preferable to assume that both his own cash and the market value of his corn could have been put out at interest, in which case interest would have been charged on the value of the corn and supplement required for each program as well as the cost of the animals.

[9]Such inputs and outputs as aftermath pasture, yard and dry lot space, veterinary services, salt, water, manure, and value of feed recovered by hogs following were ignored or considered as free goods. They could be included in the calculations if sufficiently accurate data were available. It is doubtful that the results would be affected appreciably. Similarly, it was assumed that differences in transportation cost for the different lots of animals could be ignored. (Alternately, all prices can be taken as farm prices.)

*TABLE 2—Input per $1000 of net revenue**

Process	Hay (pounds)	Pasture (acres)	Summer labor (hours)	Winter labor (hours)	Shelter (square feet)	Funds (dollars)
1	17,400	0.0	72	72	330	2,131
2	25,210	3.1	65	35	300	1,563
3	24,710	6.3	60	34	260	1,366
4	26,170	8.4	50	46	250	1,278
5	15,750	0.0	8	135	680	3,648
6	27,110	14.0	85	34	450	2,404
7	12,410	0.0	3	98	820	3,816

*Net revenue was calculated on the assumption that 102 animals were purchased, with two of them dying at the middle of their gain. Input requirements were calculated on the assumption that it was necessary to provide enough of each limited factor to carry all 102 through to completion, in case none did die. The requirement for funds was computed as the value of corn and protein supplement required for 102 animals, plus the cost of the animals. Interest, assumed to be payable when the loan is repaid, is not a drain upon the stock of funds available.

The entries in the table indicate the number of significant figures. For computational purposes more figures must be carried.

TABLE 3—Net revenue obtainable from the available quantity of each factor if devoted to a single process (Dollars)

Process / Factor	P_1	P_2	P_3	P_4	P_5	P_6	P_7
Hay	$ 9,195	*$ 6,347*	*$ 6,475*	*$ 6,114*	$10,159	$ 5,902	$12,893
Pasture	Unlimited*	19,342	9,580	7,154	Unlimited*	*4,283*	Unlimited*
Summer labor	5,766	6,427	6,961	8,307	55,726	4,933	128,025
Winter labor	12,498	25,871	26,414	19,640	6,711	26,734	9,251
Shelter	10,460	11,659	13,598	13,911	5,184	7,745	4,288
Funds	*5,725*	7,678	8,931	9,546	*3,344*	5,075	*3,197*

*Pasture not used in this process.

it also requires the most hay per animal. Our limited stock of hay will support fewer animals on Process 4 than on any other process. If we knew how much hay would be required to earn $1,000 by each of the processes, we could choose the process that made best use of our hay. Such figures have been computed for each of the limited factors. (See Table II).

It appears from Table 2 that Process 7, which uses the least hay per $1,000 of net revenue, would give the maximum net revenue that the stock of hay will permit, if there were enough of the cooperating factors. But it also appears that Process 7 imposes the heaviest drain on our use of funds. Since we have only $12,200 available that can be converted into corn, supplement, and feeder stock, Process 7 would be limited by a scarcity of funds to a net revenue figure of $3,197.[11]

In the same way, each input requirement for a process may be divided into the total quantity of each of the respective factors available to determine the maximum net revenue obtainable from the process if it were limited only by the one input. Table 4 contains the results of such a computation.

In the case of Process 7, (Column P_7 of Table 3) it appears that funds are the most severely limiting factor, so the $3,197 net revenue permitted by the funds available (the minimum of the net revenue figures in Column P_7) is the largest net revenue to be had from that process.

Each figure which is in *italic* in the table is the minimum net revenue figure for its process. It is clear that funds set the effective limit for Processes 1, 5, and 7, while hay sets the limit for Processes 2, 3 and 4.

[11] $12,200 available ÷ $3,816 required per $1,000 of net revenue = 3.197 thousands of dollars of net revenue possible.

MOST PROFITABLE PROCESS

The most profitable single process to use is the process for which the least figure is larger than the least figure for any other process. (This is the *maximum minimorum* made familiar to us by the theory of games.) In our problem this is Process 3, which is limited by its hay requirements to a net revenue of $6,475. However, the linear programming calculation reveals a program that makes a net revenue of $7,199 possible, an improvement of more than 10 percent. This program consists of:

$4,070	of net revenue from Process 4,
2,932	of net revenue from Process 1, plus
197	of net revenue from Process 7,
for a total of $7,199	of net revenue

We leave unused 26 acres of pasture, 486 hours of winter labor, and 1,334 sq. ft. of shelter space. The available stocks of funds, hay and summer labor are exhausted. Note that the optimum single process is not included in this solution. Though this would not always be the case, it is not an unusual result.

Process 3 is an approximation to an average of Process 1, light on hay and heavy on funds, with Process 4, heavy on hay and light on funds, where the weights used in averaging are the levels of net revenue to be obtained from these two processes in the optimum program.

A process intermediate between 1 and 4 in its demands upon those factors that turn out to be the limiting factors comes the closest to matching the net revenue possibilities of the optimum mixed program.

It is impossible to add a process to this solution or to expand one of the three feeding systems included within it without contracting the use of some of the other feeding systems as a means of releasing the necessary hay, funds or summer labor. Moreover, the value of the net revenue foregone by contracting Processes 4, 1, or 7 would exceed the value of the net revenue gained by expanding elsewhere.

A rough check of the last proposition may be had by referring to Table 2. To introduce Process 3, the most profitable single process, would require more hay per $1,000 of net revenue than either Process 1 or 7. It would require less hay than Process 4, but more summer labor and funds, which are likewise exhausted.

The exact adjustments required in order to add Process 3 with the least sacrifice possible are computed in the course of obtaining the

TABLE 4—Reductions in levels of other processes required in order to add $1,000 unit of process 3

Active processes	Reduction in net revenue	Factors in excess supply	Reduction in quantities to be discarded
P_1.....	$ 286.4	Pasture	.03 acres
P_4.....	784.2	Winter labor	57.6 hours
P_7.....	−64.9	Shelter	17.0 sq. ft.
Total opportunity cost of one unit of P_3	$1,005.7		

linear programming solution. The factors required to earn $1,000 in Process 3 (see Table 4) will be released if we reduce our net revenue from Process 1 by $286.4, reduce our net revenue from Process 4 by $784.2, and increase our net revenue from Process 7 by $64.9, while reducing the quantities of pasture, winter labor, and shelter to be discarded by .03 of an acre, 57.6 hours, and 17.0 sq. ft., respectively. However, we will have given up $1,005.7 in order to earn $1,000.

The $7,199 of net revenue obtainable by the optimum program is the revenue available to pay for our limited factors—hay, pasture, labor, and shelter and funds. The total net revenue of the farmer will be greater than this, for we have not credited him with the market value of the corn which he contributed. Any of his corn that is not used in the beef feeding venture can be sold; any that is used will return its market value, for each process yields a positive net revenue.

If corn is fed, its market value is returned, or net revenue would not be positive; if corn is converted into cash for the purchase of other inputs, the value of this cash is returned. Thus, adding in the $3,189 value of his 2,140 bushels of corn, we obtain $10,388 as the total net revenue for the combined beef enterprise and corn.

It is time to express our optimum program in terms of animals purchased rather than dollars of net revenue earned. The $2,932 of net revenue obtained from Process 1 represents the purchase of 32.7 calves.[12] Similarly 34.1 calves must be fed on process 4 and 3.2 two-year-olds on Process 7.

The computations have assumed that each process can be carried

[12]The purchase of 102 animals would have yielded $9,146, as in Table 2.

$$\$2{,}932 : \times :: \$9{,}146 : 102$$

$$\times = \frac{2{,}932\ (102)}{9{,}146} = 32.7 \text{ animals}$$

on at any level without affecting the ratios of input to net revenue. That is, if we assume constant returns to scale and complete divisibility for each process. It is well to dispense with the assumption of complete divisibility at this point and state our result as 34 on Process 4, 32 on Process 1, and 3 on Process 7, to yield a total net revenue of $7,107.

Note that it is not possible to round the 32.7 calves on Process 1 to 33: the quantities of the limited factors set by eliminating the requirements of the fractional steers in Processes 4 and 7 will not support even 3/10 of a calf extra in Process 1, if our input data are correct.

More serious aspects of the assumption of divisibility of processes concern the possible increase in labor cost per unit when the number of animals handled on a single feeding system is small, or the possible increase in the difficulty of managing the venture when several feeding systems are being run simultaneously. In our program, for instance, it seems unlikely that the three Process 7 animals will be worth troubling with at all, especially since they will be ready for market in February, while the other two lots will be ready around the end of July, and the early part of December.

Presumably the farmer will be able to evaluate the extra difficulty involved in carrying on more than one feeding system at a time. We can tell him what financial sacrifice he will make if he departs from the calculated optimum program.

The three animals to be fed on Process 7 would earn $184 of net revenue. But eliminating them need not be a total loss, if combining the scarce factors thus released with those set free by eliminating fractional steers will provide inputs sufficient to permit adding a calf on Process 1 or 4.

Table 5 shows the scarce inputs left over after providing for 32 animals on Process 1 and 34 on Process 4. Comparison with Table 1 shows that there will be plenty of hay to carry a calf on either Process 1 or Process 4, but that since only six hours of summer labor are still available we are restricted to Process 4. The funds available are adequate. Carrying one animal on Process 4, requires only $152.39 to pay for corn, supplement and feeder stock. If the one calf is added on Process 4, it will yield a net revenue of $119,[13] so replacing the three animals on Process 7 by one calf on Process 4 reduces total net revenue by only $184 – $119 or $65.

[13]Based on Table II. $\frac{1}{102}$ ($12,162) = $119.24

TABLE 5—Limited factors required and available when process 7 not used

Number of animals	Process	Factor		
		Hay (pounds)	Summer labor (hours)	Funds (dollars)
32	1	49,920	208	$6,115.52
34	4	106,080	204	5,180.92
Total requirement.....		156,000	412	$11,296.44
Total quantity available...		160,000	418	12,200.00
Quantity still unassigned..		4,000	6	$ 903.56

Even separating the calves into two lots after the first 50 days will probably take more labor than handling them together would. However, in this case it should be noted that only summer labor is scarce, and using both Process 1 and 4 spreads the summer labor more evenly than would the use of either process alone. (This result is fortuitous; we did not impose such a condition in setting up our problem.)

Transportation costs per animal may also be affected by the size of the lot. This would make the three Process 7 animals even more expensive to handle. As for the two calf-feeding processes, the animals can be bought in one lot, possibly at a slight saving in transportation costs per animal as compared with the best single process (No. 3), because 67 animals can be fed by using two processes, while only 55 could be fed on Process 3. On the other hand, outgoing transportation will be in smaller lots when two systems of feeding are used.

Since there are in fact many more feeding systems than the seven we have chosen, would it now be possible to devise a single feeding system that would use the resources of this farm even more efficiently than our combination of Processes 1, 4 and 7? This may well be the case. Only the animal husbandryman can judge. Even if so, perhaps our programming approach has given him some suggestions that might be useful.

SINGLE PROCESS PROGRAM

It appears likely that the ideal single process program should exhaust the supplies of hay, summer labor and funds; but that it need not exhaust pasture, winter labor and shelter.

A single feeding system for calves that would use the same quantities of the limited inputs as our optimal mixture of Processes 1 and 4

might appear quite feasible.[14] It would still have to be established that the new system would be as profitable as the mixture, for the new system would bring the calves to market at a different date. The difference in finished steer prices would generally affect the net revenues.

If beef cattle feeding is truly a case of variable proportions a single feeding system should exist which would be more profitable than the combination of systems suggested by linear programming. The question is whether this single system can be specified for a particular farm and a particular set of price relationships.

Perhaps the greatest violence done to reality in using our linear programming approximation was when we treated hay and pasture as distinct factors, not convertible into each other. Our feeding venture was limited by the exhaustion of our hay stocks, yet we had 26 acres of pasture in excess of requirements. Taking account of the possibility of converting some of the excess pasture into hay could have been done, at an increase in computing expense, by methods analogous to those developed for use in dealing with the problem which follows.

THE TWO-PRICE PROBLEM[15]
(Discontinuous Input Markets)

In reality, the farmer often finds that input markets are not perfect from his point of view. The price he must pay when he buys a certain commodity is above the price he can get when he sells. We shall call such a market discontinuous—at some point (in this case where the farmer switches from seller to buyer) there is a sudden jump in the price.

To analyze this situation, let's return to the same farm, but this time assume that there is a market for hay as well as for corn, and that in each of these markets the farmer receives a lower price if he sells than he must pay if he buys. We handle this problem by distinguishing two types of hay and two types of corn, with a different price for each type.

Assume that corn can be sold for $1.49 per bushel, but would cost $1.64 if purchased, and that hay will sell for $16 per ton, but would cost $20 per ton if purchased. Hay produced on the farm

[14]Effectively replacing the two-year-old consumption of inputs would be more troublesome.
[15]The author is indebted to Professor Glenn Johnson for suggesting this two-price problem.

must now be valued at $16 per ton, as there is now the alternative of selling it. Each of the feeding systems in the former problem becomes four in the present problem.[16]

CHANGES REQUIRED

The list of limited factors will require some changes. Hay as such is no longer limited, but low-priced hay is limited to the 80 tons grown on this farm. Whereas formerly corn and cash were equivalents we must now specify them separately: Our farmer has $1,511.44 of his own cash, plus 149,798 pounds of corn.[17] He is willing and able to borrow $7,500.

The limit on funds available now becomes $13,480.00, for he has available not only his own $1,511.44 and the $7,500 he can borrow, but also the sales value of the corn *and hay* grown on his own farm ($3,188.56 and $1,280.00, respectively). In effect, we assume that his corn and hay are converted into cash at their selling prices. The cash is then used to buy whatever is desired, subject to the limitation that purchases of corn and hay at these low prices are possible only in the amounts of 2,139.97 bushels and 80 tons, respectively. If more corn and hay are desired, the higher buying prices of $1.64 per bushel and $20 per ton must be paid. The other limited factors remain unchanged.

The physical budgets are unaffected by the alteration in market conditions, except as the requirement for funds is changed. Whereas in the first problem we were spending part of our fund of corn-and-cash on corn, we now must spend part of our funds on hay as well. (Our funds have been increased by the sales value of the hay grown on the farm, of course.) Similarly, in computing the net revenue from each process we must subtract the market value of the hay consumed.

No process will show a positive net return which does not more than pay for the hay, corn, and protein supplement consumed as well as the cost of the feeder stock and interest on the cost of the animals. The net return figures will be lower here than in the first problem,

[16] Instead of Process 1 we have Process 1 (a)—using low-priced (Home grown) hay and corn, Process 1 (b)—using low-priced corn and high-priced hay, Process 1 (c)—using high-price (purchased) corn and hay, and Process 1 (d)—using high-priced corn and low-priced hay.

[17] 2,139.97 bushels. At $1.49 per bushel his corn is worth $3,188.56. Adding his $1,511.44 in cash we obtain the $4,700 in cash or corn which he was assumed to possess in the first problem. This particular figure for cash was chosen because the solution obtained in the first problem required that in addition to borrowing $7,500 he should devote $1,511.44 of his own cash to the purchase of feeder stock and protein supplement. (He fed all the corn he grew.) By using these specifications in making the distinction between cash and corn we leave open here the possibility of carrying out the same program that was optimal for the first problem.

where the alternative opportunity cost of hay was zero. In comparing the profit results for the two cases we shall have to correct for this matter.

Table 6 contains the optimal solution of this two-price problem. Permitting the alternative of sale and purchase to be applied to hay as well as to corn, while limiting the opportunity to purchase corn at the low price, has led to a new optimal program. To say whether the new situation is more favorable than the old, requires careful interpretation of the net revenue figures.

In our first problem, the farmer netted $10,388, of which $7,199 was assigned to the limited factors (including hay), and $3,189 to the corn. In the present problem, we must include the value of both hay and corn grown on the farm, since the market value of each was subtracted in computing the net revenue of a process. Thus the farmer nets $10,976, of which $3,189 is the market value of his corn, $1,280 is the market value of his hay, and $6,507 is assigned to the limited factors. The altered market opportunities have increased the return available to the farmer by nearly six percent.[18]

The nature of the solution has also changed. No longer is the pasture unused while the feeding program is limited by a scarcity of

[18]Over 8 percent of the former return to beef cattle and hay.

TABLE 6—The two-price problem: optimal solution

	Process	Level of process	Net revenue at unit level	Net revenue from process	Number of animals to be purchased
Active processes	P_{4a} (Low-priced hay and corn)	4.185	$1,000.00	$4,185	44.2
	P_{3b} (High-priced hay, low-priced corn)	1.216	939.76	1,142	13.8
	P_{3a} (Low-priced hay and corn)	.818	1,000.00	818	8.7
	P_{7b} (High-priced Hay, low-priced corn)	.372	972.76	361	6.9
	Total			$6,507*	73.6

	Factor	Quantity of limited factor unused
Disposal processes	Winter labor	536 hours
	Shelter	1,189 square feet
	Low-priced corn	34,440 pounds

*Discrepancy in total caused by rounding error.

hay. Curiously enough, it was when we relaxed the limitation on hay that we became able to use all the pasture profitably. Now that additional hay can be purchased, it is profitable to substitute Process 3 for Process 1, meeting the extra hay requirement of Process 3 by selling some corn[19] and buying (high-priced) hay and more stock with the proceeds.

The dry lot feeding of Process 1 has been replaced by the pasture-using Processes 3 and 4. Process 1 required the largest amount of funds of any of the calf-feeding systems; we have now shifted to the two Processes that require the least.

SUMMARY

In this paper linear programming has been used, not only to determine the optimum combination of processes, but also as a means of discovering the significance of particular market opportunities in conjunction with given technical opportunities and given amounts of limited factors. A change in the market opportunities available with respect to hay and corn converted an excess of pasture into an asset with a high imputed income.

This was not the only alternative available which would have made use of all the pasture, and it may not have been the most profitable one. Certainly the alternative of converting some unused pasture into hay would be worth considering, but until this possibility is explicitly written into the problem we cannot know whether it represents further possibilities of increased profit or not.

Whatever that result might turn out to be, linear programming has already shown itself capable of providing new insight and solutions that otherwise might have been overlooked. Is it immediately obvious that the excess of pasture land that prevailed in our first problem could be eliminated, with profit, by arranging to buy more hay? The general equilibrium approach implicit in the programming formulation permits some of the more complicated relationships between variables to show themselves.

[19]Some 460 bushels, if we compute the figure.

GREEN-CHOPPING vs. GRAZING OF FORAGES ON MICHIGAN DAIRY FARMS[1]

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Progressive dairy farmers are continually testing out new feed production and feeding practices that appear profitable. In recent years, Michigan dairymen have shown interest in daily chopping and hauling green forage to their cows during the pasture period.

This practice, commonly referred to as "green-chopping", "zero-grazing" or "soiling" has been highly publicized the past two years. However, very little research has been done to show where this system fits in best and what the expected costs and benefits are compared to the more conventional system of grazing.

The need for more information about the practice of green-chopping prompted a study of forage production, harvesting and feeding practices, forage harvesting investments and costs, and milk production responses on two groups of dairy farms. Green-chopping forages was practiced on one group of farms and the more conventional system of grazing forages was followed on the other farms.

RESEARCH METHODS USED

Twelve dairy farmers who expected to chop their forages during the 1954 season were selected for the study. These farmers had been interviewed in a dairy adjustment study during 1953, or they had been contacted through county agricultural agents. Only nine of them continued to chop forages the entire period of study. These nine were paired with an equal number of dairy farmers who grazed their livestock.

[1]Contribution from the Department of Agricultural Economics of Michigan State College and the Production Economics Research Branch of the Agricultural Research Service, U. S. Department of Agriculture. The author, who is jointly employed by the two agencies, acknowledges the helpful suggestions received from several members of the Departments of Farm Crops, Dairy and Agricultural Economics. Richard Labadie did most of the field work on this study. The author appreciates the information obtained from the dairy farmers who cooperated in the study.

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In pairing, an attempt was made to obtain dairy farms that were nearly comparable in size of farm, kind of soil, producing capabilities of cows, and managerial ability of the operator. These farms were located in Barry, Ingham, Kalamazoo, and Livingston Counties.

Complete information was obtained from each dairyman on: (1) the livestock he kept, (2) the cropping system he followed, (3) the acres of each kind of forage, (4) forage harvesting, storage and feeding practices used, (5) labor, power and equipment requirements and costs in harvesting and feeding forages, (6) daily weights of milk sold, (7) freshening dates of all cows, and (8) other information about the operation of each farm.

CHARACTERISTICS OF THE FARMS STUDIED

CROPPING PROGRAM

The two groups of farms averaged almost exactly the same in acres of cropland.

Alfalfa-brome, red clover and sudan grass meadows accounted for 45 to 50 percent of the crop acres on the two groups of farms. Feed grains were planted on about one-third of the cropland. The farmers chopping forages devoted a slightly higher percentage of their cropland to forage crops and a smaller percentage to feed grains and wheat than did the other group of farmers.

TABLE 1—Average acreages of forages, feed grains and other crops produced, two groups of farms on which forages were chopped or grazed, 1954

Cropland used for:	Farms are which forages were:	
	Chopped	Grazed
Forage		
Alfalfa-brome	81.2	74.6
Red clover	1.7	4.7
Sudan grass	5.3	1.3
Rye	——	2.9*
Total	88.2	80.6
Corn silage	12.1	10.6
Corn for grain	31.3	41.0
Oats and barley	24.6	27.6
Wheat	14.7	18.9
Miscellaneous	5.1	1.8
Total Cropland	176.0	180.5

*Rye was used for early grazing and then plowed down for corn or sudan grass on two farms.

Fig. 1. The last of the sudan grass chopped from the first crop became quite mature on this farm. It becomes a problem in keeping a balance between the forage supply and the livestock needs throughout the season.

About 92 percent of the meadows were alfalfa-brome on both groups of farms (Table 1). Red clover accounted for only a small percentage of the meadow crops, being grown by only one of the nine farmers green-chopping and two of the farmers grazing their forages.

Sudan grass was grown by four dairymen for green chopped feed and grass silage. About 50 percent of the green chopped feed was supplied by sudan grass on two of these farms. Sudan grass was grown for pasture by one of the dairymen in the grazing group.

Two dairymen used an average of 13 acres of rye for early season pasture. The rye was plowed down as a green manure crop for corn on one farm and plowed down for sudan grass pasture on the second farm. Using rye on the same land as sudan grass often results in poor stands of sudan grass due to the loss of reserve moisture.

LIVESTOCK PROGRAM

Dairying was the major enterprise on all 18 farms studied. Most of the crops produced, except wheat, were fed to the dairy cattle. The farmers green-chopping their forages averaged 33.3 cows per farm compared to 26.2 cows for the other group of farmers. Size of

herd ranged from 21 to 63 cows on the farms where forages were chopped, and from 16 to 43 cows on the farms where forages were grazed. There were six Holstein and three Guernsey herds in each group of farms.

FORAGE HARVESTING AND FEEDING PRACTICES

The 18 farmers in the study were rated as to their success in using improved practices in producing and utilizing forages. Of the nine farmers green-chopping their meadows, three were rated as excellent, two as medium and four as only fair. Five of the nine farmers grazing their cows were rated as excellent and the other four as only fair. Forage practices are discussed in terms of what the group average used, as well as what the most successful and least successful farmers used.

GREEN-CHOPPING FARMS

The summer feeding period began in the early part of May on most of the farms where forages were green-chopped. These farmers chopped forages for an average of 111 days and grazed forages for an additional 25 days, making a total of 136 days. The shortest chopping period on any one farm was 90 days and the longest was 154 days.

Seven of the nine farmers grazed their cows on pasture part of the season. On some farms, this grazing occurred before the chopping began. On other farms, cows were turned out to graze after green-chopping operations were terminated.

Five of the nine farmers who green-chopped their forages ran out of material to chop on or before September 15. Thus, they were forced to turn their cows out to graze, or to chop fresh corn. The period of study ended September 30. Only two farmers chopped meadows beyond this date.

Two of the three farmers who were most successful in their green-chopping operations used sudan grass as the major source of chopped material. Sudan grass has the desired characteristic of quick re-growth during the seasons of warm weather.

The farmers who chopped and hauled forages to their cows supplied each cow with about one-fourth acre of full-season pasture and one-half acre of first crop chopped material (Table 2). Four of these farmers fed grass silage and six fed hay during part of the

TABLE 2—Average acres of different forage crops utilized during summer feeding period, 1954

Forage crops used:	Farms on which forages were:			
	Chopped		Grazed	
	Acres per farm	Acres per cow	Acres per farm	Acres per cow
First crop meadows				
Pasture (full season)	8.0	.24	33.3	1.27
Chopped forage	16.7	.50	——	——
Grass silage	5.1	.16	2.2	.08
Hay	2.3	.07	2.3	.09
Total	32.1	.97	37.8	1.44
Second crop meadows				
Pasture*	23.8	.71	58.6	2.24
Chopped forage	30.9	.93	——	——
Total	54.7	1.64	58.6	2.24
Chopped corn	1.4	.04	.6	.02

*Includes forages grazed entire season as well as those grazed only after the first crop had been harvested.

summer feeding period. These first crop forages added together provided nearly an acre per cow.

Three of the dairymen used as little as one-half acre of first crop forages per cow. Two of these dairymen appeared to underfeed their cows at least part of the summer period. The other six dairymen green-chopping forages used from three-fourths to more than one acre of first crop forages per cow.

A total of 55 acres of second-crop forages were used for pasture and green-chopped feed. Four farmers fed from 1 to 5 acres of chopped corn the latter part of the summer feeding period when there were no other forages to chop.

GRAZING FARMS

The summer feeding period started about two weeks earlier on the farms that grazed their forages compared with those that green-chopped their meadows. The nine farmers started grazing their cows from the early part of April until the middle of May. The pasture season started in early April on three farms on which successful pasture practices were used. Rye provided early pasture for a two-

to-three week period. The other two dairymen using successful pasture practices started grazing their cows in early May.

The group of farmers who grazed their cows had a pasture season of 156 days (up to September 30). All of these dairymen continued to graze their cows at least part of October.

The farmers who grazed their cows used an average of about 1¼ acres of full-season pasture per cow (Table 2). Four farmers used about 1 acre per cow and five used from one and one-fourth to one and three-fourths acres per cow. Pastures were supplemented with grass silage on two farms and with hay on six farms. Four farmers fed from 1 to 2 acres of corn silage the latter part of the pasture season.

An average of somewhat more than 1.4 acres of first crop forages were supplied per cow. The dairymen who green-chopped their forages used about 70 percent as many acres of both first and second crop forages per cow as the dairymen who grazed their forages.

About 2 acres of forages were harvested per cow for the barn-feeding period on both groups of farms. The total acres of all forages harvested per cow for the entire year averaged about 3 acres on the farms where green-chopping was practiced and about 3.5 acres on the farms where the cows were grazed.

FORAGE EQUIPMENT AND INVESTMENTS

GREEN-CHOPPING FARMS

The total investment in forage harvesting and feeding equipment was almost twice as high on the farms on which forages were chopped (Table 3). This was due to (1) higher costs of chopping and feeding equipment and (2) a duplication of forage harvesting equipment on some of the farms. Three of the nine farmers who chopped forages owned both baling and chopping equipment.

Only four of the nine farmers harvested all of their forage with chopping equipment. Two hired all of their hay baled. The five farmers who baled their hay did so largely because of the greater ease in feeding baled hay. The nine farmers chopped an average of 66 acres of first crop and 44 acres of second crop green-chopped material, hay, grass and corn silage. This was forage harvested for both summer and barn feeding periods.

The investment in additional equipment in feeding the green-chopped material was relatively low. The self-feeding wagons used

TABLE 3—Investment in forage harvesting equipment, 1954

Equipment*	Farms on which meadows were:			
	Chopped		Grazed	
	No. farms with this equipment	Present value (av. for farms owning)	No. farms with this equipment	Present value (av. for farms owning)
Baler	3	$ 481	3	$ 435
Field chopper	9†	1,266	5	1,206
Blower	8‡	366	5	351
Chopper wagons	9	659	5	611
Self-feeding wagons	3	150	—	—
Flat wagons	3	432	4	584
Feed bunks	5	130	—	—
Total investment	—	$2,676	—	$1,475

*Includes equipment for harvesting hay, grass and corn silage, and additional equipment needed in feeding chopped material.
†One farmer had 2 choppers. This makes a total of 10 choppers on these 9 farms.
‡One farmer used a blower attached to wagon.

on three farms were homemade and cost about $250 to build. Five of the farmers fed the chopped material in feed bunks and one farmer unloaded the material on glazed silo staves laid flat in rows on the ground. The feed bunks cost about $260 per farm.

Fig. 2. This is one of the self-feeding wagons used by three of the farmers who were green-chopping forages.

GRAZING FARMS

Of the farmers grazing their cows, five owned chopping equipment, three owned baling equipment and one farmer hired all his hay baled. The five farmers owning chopping equipment also used it for harvesting silage. These five farmers chopped an average of 35 acres of first crop and 14 acres of second crop hay, grass and corn silage. There was no duplication of forage harvesting equipment on these nine farms.

GREEN-CHOPPING ADDS TO COSTS

Field chopping was a major expense item in the production and harvesting of forage crops (Table 4). The dairymen green-chopping their meadows spent an average of 30 minutes daily in chopping forages and an additional 30 minutes in hauling wagons to and from the field. A charge of $1.20 per day was made for the use of the tractor. This is about the hourly cost of operating a medium-sized tractor.

The cost of operating field choppers and balers was based on hourly charges associated with hours of annual use. For example, an hourly charge of $2.60 was made for the 138 hours field choppers were operated on the farms where forages were green-chopped.

An hourly charge of $4.00 was used on the farms where meadows were grazed.[2] Field choppers were operated an average of only 53

[2]Based on information from Agricultural Engineering Yearbook, Fifth Edition, 1954. Published by the American Society of Agricultural Engineers.

TABLE 4—Estimated annual variable costs per farm in producing and harvesting all forage crops, 1954

Cost item:	Farms on which meadows were:		Additional costs on green chopping farms
	Chopped	Grazed	
Chopping*	$ 657	$ 411	$ 246
Extra labor chopping	110	—	110
Baling*	130	129	1
Wagons (chopped and baled hay)	163	121	42
Self-feeding wagons	17	—	17
Feed bunks	29	—	29
Extra production costs†	141	—	141
Total costs	$1,247	$661	$586

*Includes cost of repairs, depreciation, interest, housing, fuel and oil, and a charge for the use of tractors. These costs also include custom baling and chopping.

†These additional costs resulted from the greater use of sudan grass and corn for chopped material.

hours per farm on these farms. These hourly costs include depreciation, repairs, housing, interest, and fuel and oil but not labor or the use of a tractor.

A charge of $1.00 was made for the extra hour of labor used daily in chopping and hauling meadows. A few of the farmers estimated that the extra time spent in chopping and hauling meadows was offset by the saving in time in not going after the cows. The time required to chop and haul a load of green material varied from farm to farm, determined largely by the location and accessibility of the fields chopped.

A few farmers spent as little as 15 to 20 minutes while others used more than 90 minutes to chop and haul a day's supply of chopped feed. Extra time was used by three farmers in unloading the chopped material into feed bunks. The usual time for chopping meadows was between the hours of 7:00 and 10:00 A.M., and 3:00 and 7:00 P.M.

All nine of the farmers used direct-chop equipment. Five of these farmers chopped both hay and grass silage in addition to chopping meadows daily. This necessitated changing chopper heads in shifting from direct chopping to picking up material from the windrow. This operation used up valuable time during the busy season.

One dairyman custom-hired baling and chopping to avoid this inconvenience. A dairyman with 50 cows owned two choppers to avoid this difficulty. Three farmers baled their hay, thus they did not have this problem.

Fig. 3. Feed bunks such as these were used on five farms, and proved satisfactory in feeding green-chopped material.

Self-feeding wagons and bunks added $45 per farm to annual costs. The greater use of sudan grass and corn for chopped feed added $161 to forage production costs. Alfalfa-brome is one of the lowest cost meadows since it is not necessary to reseed each year. It costs about $25 annually to produce an acre of alfalfa-brome compared with $34 for sudan grass pasture.

Chopping and hauling costs add from $13 to $18 per acre, depending on how extensively chopping equipment is used. It costs about $55 to grow, chop and haul an acre of corn for late summer feed.

Fencing costs should be reduced in the future on the farms where green-chopping is practiced. Some farmers may continue to keep fences in good condition in order to graze aftermath and other feed crops.

Forage costs were estimated as almost $600 higher on the farms where green-chopping was practiced (Table 4). These additional costs must be offset by increased livestock returns if the green-chopping practice is to show a profit over the more conventional grazing system.

MILK PRODUCTION RESPONSE

ALL FARMS

A change from barn to pasture feeding usually results in increased production of milk per cow. This is due to the more nutritious nature of the material as well as to the greater palatability, which means that increased quantities are eaten.

Milk production responses were measured on the 18 farms by comparing actual daily production (on a weekly basis) of the herd with a computed expected daily production. The daily expected production was computed by assigning weekly values for each cow's lactation period. For example, a value of 100 was given to the fourth week's expected production. This is the usual peak in a cow's milk production. As a cow's lactation period progresses, these values become smaller and smaller until they reach zero at the end of her milking period.

These weekly values for all cows in each herd were totalled. An index of daily expected production (on a weekly period) per cow was then computed, with the barn period average considered as 100. The actual daily production (on a weekly period) per cow was then cal-

culated. These daily average weights of milk were then converted to an index of actual production, with the barn period average considered as 100.

The expected production for the entire period is shown as a straight line (100). The daily variation in actual production from the expected production reflects changes in the quality and quantity of feeds, as well as changes in climatic and other environmental conditions.

The production response of cows in individual herds varied widely when chopped material or pastures were substituted for barn-fed forages. A comparison was made of the milk production responses of cows on the nine farms where the chopping program was followed, and on the nine farms where forages were grazed. Actual production showed very little variation on both groups of farms during the winter feeding period, but it tended to increase as the season progressed (Fig. 4).

The cows on the farms where green-chopping was practiced did not respond in milk production as much as did the cows on the farms where forages were grazed during the summer feeding period (Fig. 4). The peak in daily production was somewhat lower and was reached about two weeks later on the green-chopping farms. Daily milk production on these farms was greatly depressed in late June and in July. Milk production on the grazing farms was maintained at a more uniform daily rate per cow.

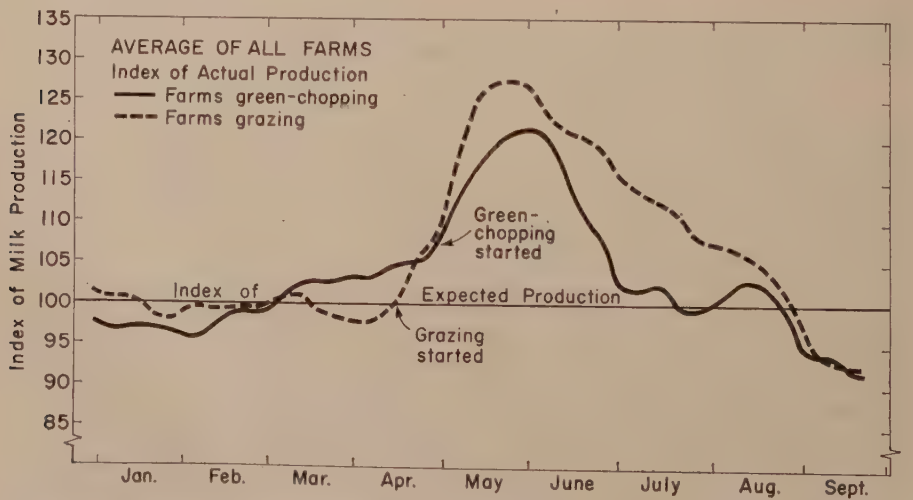

Fig. 4. Index of actual and expected daily production on farms where forages were green-chopped and grazed. Average of all farms, 1954.

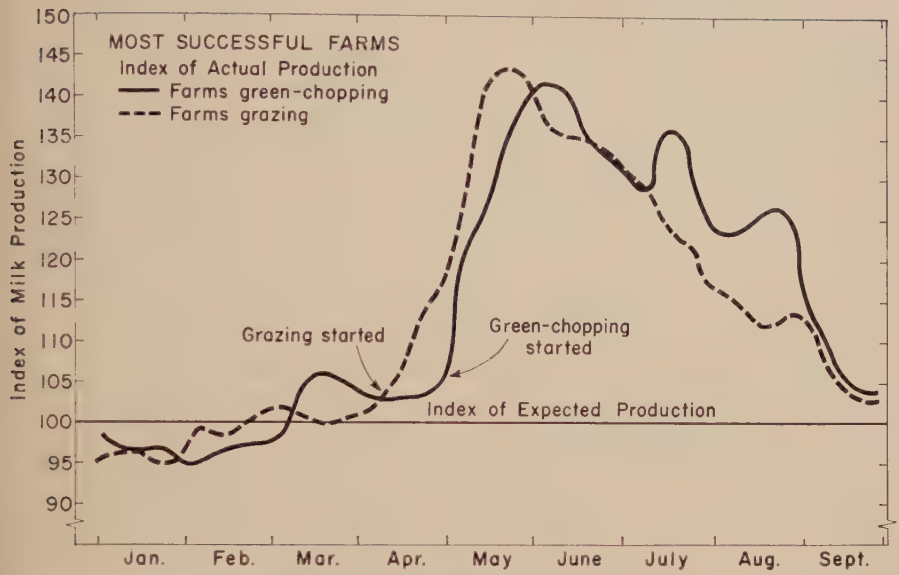

Fig. 5. Index of actual and expected daily production on farms where forages were green-chopped and grazed. Average of most successful farms, 1954.

There are two possible explanations for the poorer response in milk production on the part of the cows in the green-chopping group. The cows on these farms were about three weeks further along in their lactation period. If account is taken of these differences in the freshening pattern of the cows, these cows should have produced about 95 percent as much milk per cow per day as the cows on the other group of farms. Actually they produced only about 88 percent as much.

An important cause of this lag in milk production appeared to be poor management practices on the part of a few of the farmers chopping forages. Green-chopping was a new practice for all of these farmers. Most of them had green-chopped forages for the first time in 1954. It takes time and experience to develop a new practice. It appeared that at least two of the dairymen were under-feeding their cows chopped material. Forages became too mature before they were chopped on a few farms.

MOST SUCCESSFUL FARMS

The dairymen who were most successful in using improved grazing practices attained a peak in daily milk production about May 20 (Fig. 5). The dairymen who used the most successful chopping prac-

tices reached a peak only slightly below the other group but about two weeks later. This was due to the later start of the summer feeding period.

Both groups of dairymen maintained daily milk production at about the same level during the last half of June and in early July. However, milk production was maintained at a somewhat higher level during most of July and August on the farms on which meadows were chopped.

During most of September, daily production was down to the same level for both groups. The second peak in daily milk production, reached in July on the green-chopping farms, was largely the result of chopping new fields of sudan grass. The peak in mid-August reflected the chopping of second crop sudan grass forage.

Milk production per cow averaged about the same on both of these groups of farms.

LEAST SUCCESSFUL FARMS

The four dairymen who were least successful in chopping meadows attained a milk production response less than 10 percent higher than the barn-period average (Fig. 6). Daily production per cow fell below the expected production by the middle of June and dropped to a level of 80 to 85 percent of the expected production for the last 2½ months of the chopping period.

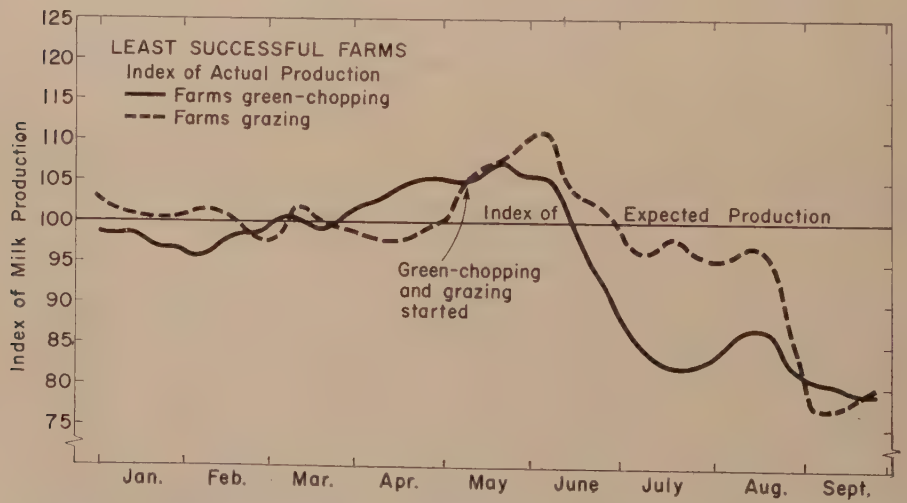

Fig. 6. Index of actual and expected daily production on farms where forages were green-chopped and grazed. Average of least successful farms, 1954.

It is believed that at least part of this drop in milk production on these four farms was the result of inadequate quantities of chopped forage supplied the cows. Good judgment and careful attention is needed to see that enough, but not a wasteful quantity of chopped forage, is supplied so that cows do not go hungry between chopping operations. The meadows on these four farms consisted of good stands of alfalfa-brome mixtures.

NET RETURNS FROM CHOPPING

Did the milk produced from the extra cows kept pay for the additional costs of chopping? These extra costs added up to $584 for the nine farms green-chopping. These dairymen kept an additional 7 cows by following the forage practices they did.

Labor and management returns per cow, calculated at present prices, are estimated at about $85 per cow for the quality of cows on the nine farms green-chopping forages. This would add almost $600 to labor and management for the additional 7 cows kept. From these calculations, it appears, that for the group as a whole, the extra returns just about paid for the additional costs.

Cost and return figures were not prepared for individual farms. It is certain that costs exceeded benefits from chopping on some farms. Chopping operations appeared to be profitable on the farms where the best practices were used.

EVALUATING THE TWO SYSTEMS

It is believed that the practice of green-chopping is better suited to some farms than others. Timeliness and skill in keeping machinery in good working condition become very important considerations. The possible conflicts in the use of labor and equipment need to be considered in selecting the best system of forage production. Highly productive forages are needed for successful green-chopping operations.

The second year of a study of soiling vs. rotational grazing carried out by the Dairy Department at the Minnesota Agricultural Experiment Station's Rosemont Station showed no difference in the milk production per acre from these two systems in 1954 when alfalfa-brome forages were used. The Minnesota Station has come to the

tentative conclusion that green-chopping or soiling does not pay unless tall, quick grown crops such as sudan grass or oats are utilized as part of the program.

The practice of green chopping appears to be particularly well adapted to dairy farms that are short of cropland relative to labor and cows. It makes possible a larger volume of business without adding more land. A farmer who has a limited labor supply and adequate cropland for producing forage crops may find the more conventional system of grazing, supplemented with grass silage and hay, the most profitable for him.

THE EFFECTS OF AGRICULTURAL PRODUCTION CONTROLS IN 1954 ON FOUR MICHIGAN FARMING AREAS

By DALE E. HATHAWAY
Department of Agricultural Economics

In 1954, for the first time since World War II, there was a serious effort to control agricultural production through production controls on important Michigan crops. There were marketing quotas on the wheat crop harvested in 1954, and acreage allotments for the 1954 corn crop. The marketing quotas for wheat meant that farmers who had wheat acreage allotments of more than 15 acres were required to comply with these allotments or pay a cash penalty for all wheat grown on acreage in excess of the allotment.

Penalties for exceeding the corn allotments were less severe, since the farmer who failed to comply only lost his eligibility for price supports on his corn crop. A survey taken from over 400 Michigan farms gives some indication of the results of these production control programs in different areas of the state.

THE AREAS AND FARMS SURVEYED

Between June and September 1954, slightly more than 400 Michigan farms were visited. The operators were interviewed regarding the various effects of production controls on their farming operations. These farms were about equally divided among four areas of the state. The census classification of the economic areas and townships which were visited within these areas are shown in Figure 1.

One of these areas was in the southern part of Kalamazoo county where wheat and corn are both important crops. The 1950 census classified about 15 percent of the farms in this economic area as cash grain farms, 29 percent as dairy farms, 14 percent as livestock other than dairy and poultry, and 24 percent as general farms.

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A high proportion of the commercial farms in this area produce both wheat and corn. From 1940 to 1950 this economic area had an expansion of about 14 percent in corn acreage and about 65 percent in wheat acreage, even though the number of farms producing corn declined nearly 20 percent and the number of farms producing wheat remained very nearly stable.

The second area was in Gratiot and Isabella counties in central Michigan. The 1950 census classified 20 percent of the farms in this area as cash grain, 30 percent as dairy farms, 5 percent as livestock other than dairy or poultry, and 22 percent as general farms. In this area, however, the number of farms producing wheat increased 20

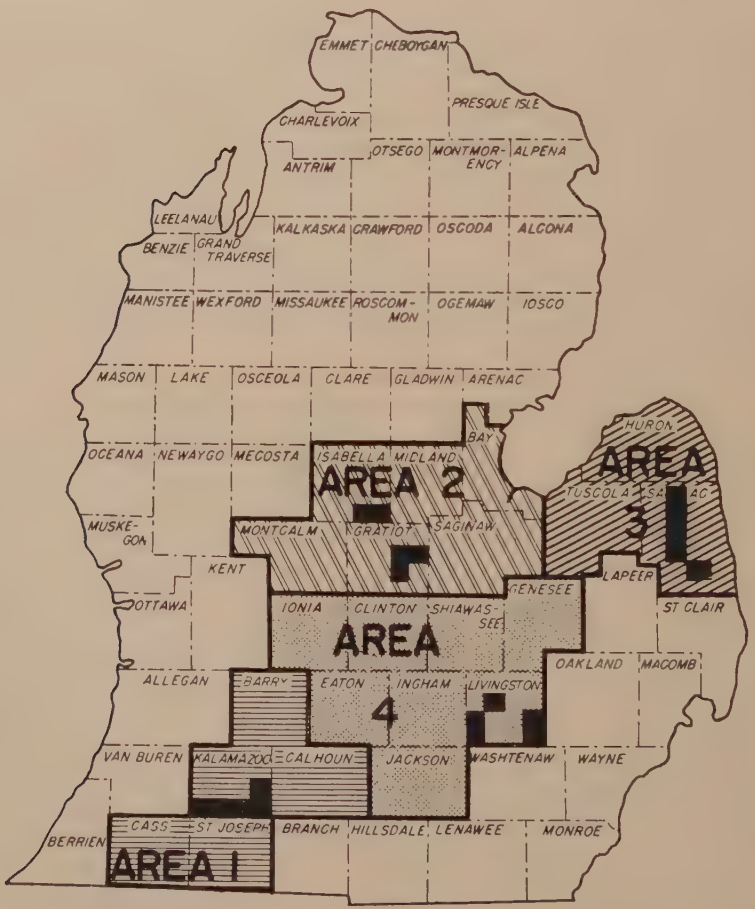

Fig. 1. Four economic areas in Michigan as defined by the census and the townships within these areas where farmers were interviewed.

percent from 1940 to 1950; wheat acreage increased by more than two and one-half times, and wheat production more than quadrupled. At the same time, the number of corn producers declined 25 percent, and corn acreage declined about 20 percent even though total production increased.

The third area studied was in Sanilac county in the "Thumb" area of Michigan. The 1950 census classified 42 percent of the farms as cash grain farms, 28 percent as dairy farms, 2 percent as livestock other than dairy, and 22 percent as general farms. This also was an area in which wheat production had more than doubled, largely because the acreage of wheat per farm about doubled. The production of corn remained almost stable, with fewer corn producers growing fewer total acres offset by increasing yields.

The fourth area was in Livingston county, a dairy area. Thirty-eight percent of the farms were classified as dairy farms in 1950; only 15 percent were cash grain, 11 percent were livestock other than dairy or poultry, and 18 percent were classified as general farms. Corn production in this area more than doubled from 1940 to 1950, due to both increased acreage per farm and increasing yields. Wheat acreage doubled during the period and, combined with increasing yields, production more than doubled.

Townships within these counties were selected with an attempt to maintain approximately a uniform soil type within each of the economic areas. A random sample of farms were drawn from the wheat listing sheets of the county Agricultural Stabilization and Conservation Committee. The acreages of wheat for 1951, 1952, 1953, and 1954 were obtained for each farm along with the 1954 allotment.

All farmers with wheat allotments of less than 15 acres were eliminated, since they were required to make an adjustment in acreage only if they wanted to be eligible for price supports. Consequently, the farmers interviewed were operating farms larger than the average shown by the census, but were quite typical of commercial farms in Michigan. Since about 80 percent of the wheat produced in Michigan is produced on farms raising 15 acres or more of wheat, the exclusion of the farms not having to make an adjustment because of production controls was not serious.

ACREAGE SHIFTS UNDER THE CONTROL PROGRAM

While the total acreage of cropland for the 400 farms was approximately the same in 1954 as in 1953, there were significant shifts in

TABLE 1—Percentage of cropland in different crops on sample farms in four areas in Michigan, 1953 and 1954

Area	Wheat	Corn		Oats	Rye	Barley	Dry-beans	Sugar-beets	Soy-beans	Potatoes	Clover		Alfalfa			Permanent pasture	Summer fallow	Clover seed	Idle	Other
		Grain	Silage								Hay	Pasture	Pasture	Hay	Silage					
	Percent of cropland																			
Kalamazoo County																				
1953	27	25	1	16	0	.08	.20	0	.11	.04	8	4	2	2	.10	1	3	2	5	3
1954	17	25	1	17	.49	2	.22	0	1	00	10	4	2	3	.13	2	3	2	7	3
Gratiot and Isabella County																				
1953	25	22	2	12	.16	1	15	1	2	0	3	2	2	7	.27	1	1	1	1	2
1954	15	22	2	12	.01	1	22	1	3	0	3	2	3	8	.25	1	1	1	1	2
Sanilac County																				
1953	22	3	5	13	.15	.18	8	.48	.19	.14	13	9	2	7	.05	2	7	1	4	3
1954	14	7	4	16	.14	.42	12	1	.18	.01	13	9	2	9	.21	2	3	1	3	3
Livingston County																				
1953	25	16	3	10	.41	.14	.15	0	.14	0	6	4	4	11	1	2	5	3	6	3
1954	16	18	3	12	.31	.27	.69	0	.12	.01	8	4	4	12	2	2	5	3	7	3

acreages of various crops. In 1953, wheat made up 25 percent of the harvested acreage but declined to 16 percent in 1954. This was offset by an increase in corn for grain from 17 to 19 percent of the crop acreage; in oats, from 13 to 14 percent; in dry beans, 6 to 9 percent; in clover for hay, 7 to 9 percent; and clover for pasture, 4 to 5 percent. There were also increases in the acreage of rye, barley, and sugar beets on these farms, but these crops accounted for a relatively small percentage of the total cropland.

The shifts in acreages under the control program differed considerably in different areas of the state (Table 1). In Kalamazoo county wheat acreage declined from 27 to 17 percent of the cropland. The proportion of cropland planted to corn in 1954 remained the same as in 1953. There were sizable increases in idle cropland, clover for hay, barley, and alfalfa for hay.

In the central Michigan area, the acreage shifts were somewhat different. Wheat acreage declined, and corn acreage remained about the same proportion of cropland as in 1953. The greatest increase was in dry bean acreage which rose from 15 to 22 percent of the cropland. There was also an increase in soybeans, clover for hay, and in alfalfa. This was an area in which dry bean acreage had declined since World War II, and the controls on wheat sharply reversed this trend.

In Sanilac county, which is not in the commercial corn area and therefore not subject to acreage allotments on corn, there was a sharp increase in corn and oats acreage. There was also an increase in the acreage of dry beans over 1953, although not as much as in the central Michigan area. In addition to the reduction in wheat acreage, there was also a substantial reduction in the land in summer fallow associated with it.

In the Livingston county dairy area, most of the acreage shifted out of wheat went into feed products. There was an increase in corn for grain, oats, clover for hay, and alfalfa.

In the Kalamazoo county sample and the central Michigan area, the corn allotments were at least partially effective in preventing farmers from planting corn on acreage diverted from wheat. Thirty-four percent of the farmers interviewed in these two areas had complied with their corn allotment. Many who complied said they did so because they wanted price supports on corn. This was especially true in the central Michigan area. These reductions in corn acreage were partially offset by farmers in the area who had not complied with corn

allotments, many of whom had increased corn acreage. In these cases, the major reason given for not complying with allotments was the need for the corn for livestock feed.

Thus, where corn was produced as a cash crop, there was a tendency to switch to other cash crops when possible or to alternative grain crops. Where there were no controls on corn or where the corn was fed, much of the acreage diverted from wheat went to corn. The Kalamazoo area was the only area in which there was any increase in idle cropland, and this was probably only a one-year reaction since some of the adjustments require longer periods.

THE EFFECTS OF CONTROLS ON TOTAL AGRICULTURAL PRODUCTION

It is very difficult to separate the effects of controls from weather, the amount of fertilizer used, farming practices, and other factors influencing production. It is also difficult to compare total production when the relative amounts of products produced in different years change. One method of comparison is by comparing the total pounds of Total Digestible Nutrients (TDN's) produced each year.

Between 1953 and 1954, the TDN's produced on the farms visited increased about 6.6 percent. In 1953, about 70 percent of those TDN's were from wheat, corn, oats, soybeans, and barley, with field beans furnishing another 4 percent. In 1954, these same grains only made up 66 percent of the TDN's produced on these farms, with field beans adding another 6 percent.

The changes in total production of TDN's from 1953 to 1954 differed greatly from area to area. The farmers interviewed in Kalamazoo county increased their production by 9.7 percent; those in the central Michigan area increased by 2.5 percent; those in Sanilac county increased by 18.6 percent, while those in Livingston county decreased by 3 percent.

The composition of the TDN's also varied, depending upon the area. In the Kalamazoo county sample, 84 percent of the TDN's produced in 1953 came from grains; the figure was 86 percent in 1954. In the central Michigan area, 74 percent of the TDN's produced in 1953 were from grains compared with 69 percent in 1954. In Sanilac county, the respective percentages for the two years were 48 and 46, while in Livingston county the figures were 64 and 57 percent.

While it is difficult to evaluate the effects of weather on total production from year to year, it is apparent that the weather differences within the state were not great enough to account for the variations between these areas. It appears that the production controls were least effective in controlling production in Sanilac county where a high proportion of the farms were cash grain; partially because those farmers had an alternative supported crop, dry beans, and partially because they were not subject to corn allotments.

If corn allotments had been applied in this area, or if some type of cross-compliance had been in effect between crops, it is likely that the adjustments would have been different. The reduction in TDN's produced in Livingston county appears to be the result of it being either uneconomic or impossible for farms primarily oriented around dairy production to shift to products other than forage crops or lower value feed grains.

THE UTILIZATION OF PRODUCTION UNDER CONTROLS

In addition to obtaining the total production on the sample farms in 1953 and 1954, farmers were asked about the disposition of this production. About 47 percent of the TDN's produced in 1953 were fed to livestock. Farmers planned to feed about 51 percent of their 1954 production, with the percentage varying between the different areas.

In Kalamazoo county, farmers said they had fed 38 percent of their 1953 production and planned to feed 45 percent of their 1954 production to livestock, indicating an increase in livestock feeding of some proportions. There was very little change in the source of TDN's they planned to feed in 1954 and in 1953. In 1953, 69 percent of the TDN's fed came from grain and in 1954, they expected to have 71 percent of the TDN's from grain. This would suggest that they expected to increase primarily their concentrate consuming livestock.

In the central Michigan area, farmers fed 33 percent of the TDN's produced in 1953 and expected to increase this to 36 percent in 1954. The proportion of this feed coming from grain fell from 58 to 55 percent.

In Sanilac county, farmers fed 62 percent of the TDN's produced in 1953 and planned to feed the same proportion in 1954. However, the percentage of TDN's fed that came from grain increased from 28 to 35 percent due to the increase in corn production.

In the Livingston county sample, the farmers expected to feed a higher proportion of the TDN's produced in 1954; 69 compared to 61 percent in 1953, probably because of the shift toward roughages. This was also indicated by the slight decline, from 46 to 45 percent, in the proportion of the feed that came from grains.

The utilization of some of the individual crops is also of some importance. Along with the decline in wheat production of about one-third, the farmers expected to reduce the wheat used for feed by 44 percent. This also varied by area. In Kalamazoo county, farmers planned to reduce the use of wheat for feed by 53 percent; in the central Michigan area, there was little change; in the Sanilac sample, they planned to feed one-third less wheat; and in Livingston county, 44 percent less than in 1953.

Farmers in all of the areas planned to increase the feeding of corn. These increases ranged from 9 and 11 percent respectively in the central Michigan and Livingston county samples, to one-third in Kalamazoo and two-thirds in Sanilac county.

Since the prices which the farmers interviewed received for crops sold is not available at this time, it is not possible to completely evaluate the effects of these controls upon their farm income. The expected sales of the individual crops can be reported, however. Wheat was the only important crop of which farmers expected to sell substantially less in 1954 than 1953. On the average, they expected wheat sales to decline one-third, varying among areas. In Kalamazoo county, they anticipated a 39 percent reduction in the amount of wheat sold; in the central Michigan area, 28 percent; in Sanilac county, 16 percent; and in Livingston county, 47 percent. In spite of the acreage allotments on corn, the sample of farmers in Kalamazoo county expected to sell 37 percent more corn. The farmers in the central Michigan group expected to reduce corn sales by 1 percent, and those in Livingston county expected to sell 8 percent less. Outside the commercial corn area in Sanilac county, the farmers expected to increase their corn sales more than twice the 1953 figure. Even so, the bulk of the increased corn produced for sale came from Kalamazoo county where compliance with corn allotments was comparatively high.

In addition to the expected sale of corn, the farmers interviewed expected to increase their sales of all of the other feed grains and dry beans. Many of the stated plans regarding dry beans were undoubtedly altered later by the poor harvest season that sharply reduced the crop.

An increase of one-third was planned in the amount of oats to be sold, 81 percent for rye, and of two and one-half times for barley. In addition, nearly one-half of the farmers said they planned to sell hay. These increases were largely because Michigan farmers raise these crops for feed and normally sell only amounts in excess of feeding needs.

Even if the crops that the farmers planned to sell were valued at their 1953 prices, their total income from these sales would have been reduced by the substitution of lower valued grains for wheat. In addition, the extra supplies of some of these crops have resulted in somewhat lower prices. Complete evaluation of the effects of these changes will not be possible until the prices received for the 1954 crops are available.

CONCLUSIONS ON THE FIRST YEAR OF PRODUCTION CONTROLS

It appears that the marketing quotas on wheat were successful in the first year in their attempt to reduce the production of wheat on farms subject to marketing quotas. However, they did not appear to have any effect upon total agricultural production on the sample farms. Wheat controls appear to have merely resulted in changing the production patterns on these farms toward feed grains and will presumably result in an increase in livestock production.

In general, it appears that the areas in which most of the farms were oriented around dairy herds had the most difficulty in maintaining production under the controls. Those areas with a relatively higher proportion of cash grain farms were more successful in offsetting the controls, partially because many of them were in an area which had no acreage allotments on corn.

It appears that the control programs will result in a lowering of income on the sample of farms, at least in the short-run. If the extra feed produced results in an increase in livestock production, it is likely that the income of livestock producers will also be reduced over a period of time.

The differences in adjustment between the four sample areas studied suggest that the impact of controls may be quite different, depending upon the enterprises around which the farm is organized. Further analysis will be done on this basis, disregarding the geographical location of the farm.

EFFECT OF BETA-PROPIOLACTONE ON CELLS OF THREE COLONIAL TYPES OF BRUCELLA

I. Bactericidal action. II. Activity of enzyme systems. III. Immunogenic property.

By I. FOREST HUDDLESON
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IN A SEARCH for a satisfactory agent for sterilizing whole blood and blood plasma that was relatively non-toxic and produced no serious alterations in the blood constituents after its addition, Hartman *et al.* (1951), (1954) found that beta-propiolactone was the most acceptable and showed greater promise than any one of 400 other agents studied.

The presence of 1.5 mg./ml. of beta-propiolactone in ACD plasma or whole blood inactivated the following viruses in 1 percent suspension of brain tissue: New Jersey vesicular stomatitis, lymphocytic choriomengitis, St. Louis encephalitis, rabies, Newcastle disease, SK strain of murine polio and encephalomyocarditis. Sheep serum containing 2 mg./ml. or less, killed 5×10^7 organisms/ml. of the following bacteria: *Aerobacter aerogenese, Escherichia coli, Salmonella typhosa, Micrococcus aureus, Sarcina lutea,* and *Pseudomonas aeruginosa.* Sterilization was more effective when the mixtures were at a pH below 7 and held at a temperature of 37° C. (Hartman, *et al,* 1951.)

Further studies (Hartman, LoGrippo and Kelly, 1954) revealed that the administration of massive doses of beta-propiolactone-treated plasma (1.5-6 mg./ml.) to mice, dogs, and rabbits produced no demonstrable toxic effects.

Recently, Mack and Chotisen (1955) inactivated Newcastle disease virus by the presence of beta-propiolactone and obtained an inactivated-virus vaccine that produced a highly satisfactory immunity in young chicks against Newcastle disease.

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The present study was undertaken to determine the effects of beta-propiolactone on the viability and other properties of cells of different colonial types of *Brucella.*

GENERAL PROCEDURES

Bacterial cells of S and R colonial types of *Brucella abortus, Brucella suis,* and *Brucella melitensis* were grown for 48 hours on peptone M agar and suspended in sterile distilled water containing 0.5 percent NaCl and 0.05 percent tryptose. The suspensions of the S and R types contained approximately 10^{11} living cells/ml.

The mucoid type of *Br. suis* was grown in a liquid medium containing tryptose and peptone M. At the end of the incubation period, the cell suspension was adjusted by turbidimetric means to contain 10^{11} cells ml. Live cell counts from agar platings indicated 6×10^{10} cells/ml. of the total were living. The M type cells were not removed from the liquid culture medium for inactivation studies.

EFFECT ON VIABILITY

In experiments to determine the effect of beta-propiolactone on the viability of cells, 50-100 ml. of each of the suspensions in Pyrex containers were brought to 37° C. in a water-bath. Undiluted beta-propiolactone was then added to the suspensions to obtain final concentrations of 0.02, 0.05, 0.1, 0.15, 0.2, 0.3 ml./100 ml. The containers were sealed with rubber stoppers, placed at 37° C., and shaken vigorously by hand at intervals of 10 minutes for one hour.

The containers were then held for 24 hours at 25° C. without shaking and stored at 4° C. At intervals of 30 minutes up to 2 hours after adding the agent, a 1 ml. sample was removed from each container and 0.5 ml. flooded over the surface of 2 agar plates. The inoculated plates were incubated for 5 days before discarding.

From many trials it was found that a minimum of 0.1 ml./100 ml. of beta-propiolactone was required for the rapid inactivation of all living brucella cells of the S and R types. Agar surface platings of 0.5 ml. amounts at the end of the first 30-minute period produced approximately 100 colonies. At the end of the first hour there were none.

Cell suspensions of the M type in the liquid culture medium in which they were grown required 0.15 ml./100 ml. and an incubation

period of 20 hours at 25° C. for complete inactivation. This may have been due to the nature of this type of bacterial cell, or to the effect of medium constituents on the agent.

In addition to plating the treated cell suspensions directly on agar plates, a portion (10 ml.) was centrifuged, the supernatant removed, and the packed cells washed twice with sterile saline solution to remove uncombined beta-propiolactone. The washed cells were then resuspended and surface plated on agar. In no instance in which the original cell suspensions were found sterile on plating were viable cells obtained after the centrifuge washings.

ACTIVITY OF ENZYME SYSTEMS

The effect of beta-propiolactone on the activity of several enzymes known to be present in viable *Br. suis* cells is illustrated by the data presented in Table 1. The enzyme activity examinations were made on untreated and treated cell suspensions (10^{11} cells/ml.) of the same age. Presence or absence of viable cells was determined on all suspensions examined.

TABLE 1—Effect of beta-propiolactone on enzyme systems in cells of two colonial types of Br. suis.

Colonial type	B. P. L. conc. percent	Interval after treatment	Enzyme system examined			
			Urase	Sulfidase	Catalase	Tetrazolium reducing
S	0	0	5 min. 4+	24 hrs. 4+	30 min. 4+	4+
S	0.1	24 hrs.	4+	4+	4+	–
S	0	0	4+	4+	4+	4+
S	0.1	30 days*	4+	4+	4+	–
M	0	0*	4+	4+	4+	4+
M	0.15	24 hrs.	4+	4+	4+	–
M	0	0*	4+	4+	4+	4+
M	0.15	30 days*	4+	4+	4+	–

* Stored at 4°C.

Urase activity was determined by placing 0.1 ml. of suspended cells on the surface of an agar slant of the medium described by Christensen (1946). Production of H_2S was determined by the degree of blackening of lead acetate paper strips after placing 0.1 ml. of the suspensions on tryptose agar slants. Catalase was determined by a quantitative method (1943). The activity of a reducing enzyme that is associated with the viability of cells was determined by its ability to reduce 2, 3, 5-triphenyltetrazolium to a red formazan.

It is of interest to note that the activity of only one of the four enzyme systems examined was affected to any extent after the bacterial cells were rendered non-viable by the concentrations of beta-propiolactone mentioned in the table. However, all of the enzyme systems studied were inactivated within the first 24-hour period by using higher concentrations (0.2 to 0.3 percent) of the agent in cell suspensions of the same density.

IMMUNIZING VALUE OF A BR. SUIS MUCOID-TYPE VACCINE INACTIVATED WITH BETA-PROPIOLACTONE

In Table 2 are presented data which illustrate the possibility of producing a satisfactory brucella vaccine from a mucoid colonial type of *Br. suis* after the cells are inactivated with a suitable concentration (0.15 percent final dilution) of beta-propiolactone. Each of 10 guinea pigs in six groups were injected subcutaneously with 10^{11} cells/ml. Four different lots of cells were used for the six groups. With the exception of group 505, the cells were injected three to four weeks after inactivation. Group 505 was given the first injection of a lot that was stored at 4° C. for 3 months to determine the effect of storage on its immunogenic value.

After an interval varying from 3 to 4 weeks, each pig in a group along with 10 controls per group, was injected subcutaneously with more than 50 infecting doses of *Br. abortus* strain 2308. The pigs were killed 4 weeks after exposure and the various internal organs cultured for living *Br. abortus*. The presence of infection in the pigs was based on recovery of viable *Br. abortus* from one or more organs and presence of specific agglutinins in the blood serum in a titer of 1:25 or higher.

Also recorded in Table 2 for comparison are the results of attempts made in the past to immunize guinea pigs against experimental bru-

TABLE 2—Immunization of guinea pigs against brucellosis using living or killed cells of a mucoid colonial type of Br. suis.

Group	Vaccine type	Route of injection	Exposure number of cells‡‡ subcutaneous	Results§§ Number vaccinated / Controls	Results§§ vaccinated infected / Controls infected
432	Living	Subcut. 1-injection	10^4	10/10	5/9
420	Living	Subcut. 2-injections**	2×10^3	10/10	2/10
447	Formalin inactivated*	Subcut. 1-injection	10^4	10/10	7/9
451	Heat inactivated†	Subcut. 1-injection	5×10^3	10/10	10/10
478	Ethanol inactivated‡	Subcut. 2-injections**	15×10^3	10/10	9/10
500	B.P.L. inactivated§	Subcut. 2-injections	4×10^3	8/6	2/6
501	B.P.L. inactivated§	Subcut. 2-injections	4×10^3	10/10	2/9
502	B.P.L. inactivated‖	Subcut. 2-injections	4×10^3	10/10	1/9
503	B.P.L. inactivated‖	Subcut. 2-injections	10^4	10/10	2/9
504	B.P.L. inactivated‖	Subcut. 1-injection	10^4	10/10	6/9
505	B.P.L. inactivated‖	Subcut. 2-injections**††	8×10^3	10/10	3/10

*Final dilution 0.8 percent.
†56°C. for one hour.
‡Final concentration 30 percent, ethanol removed after 10 minutes exposure.

Footnotes for Table 2, con't.

§Beta-propiolactone concentration 0.3 percent. ‖0.15 percent.
**Interval between injections, 10 days.
††First injection given 3 months after preparation and storage at 4°C.
‡‡Br. abortus strain 2308 injected 3–4 weeks after injection of vaccine.
§§Killed and cultured 4 weeks after exposure.

cellosis with living cells of the mucoid type and with cells of the same type after inactivation by either chemical or physical means. In comparing the results obtained from the injection of the beta-propiolactone-inactivated vaccines with those prepared by other means, it is quite obvious that the former, when given in two separate doses, is superior to those prepared by other methods of inactivation. From the results obtained on pigs in group 504, it is evident that one injection of the beta-propiolactone vaccine does not elicit a high degree of resistance against brucellosis.

In order to determine whether or not *Br. suis* cells of the mucoid type inactivated with beta-propiolactone increased the activity of blood constituents generally associated with the immunity mechanism, each of two rabbits was given two subcutaneous injections of 10^{11} mucoid cells at intervals of 10 days. Before the injections were given, citrated blood plasma of the rabbits in a 1:7 dilution in a suitable liquid culture medium (total 21 ml.) failed to inhibit the growth of 30 cells of a CO_2 dependent strain of *Br. abortus* during a 3-day period of incubation. Furthermore, in whole blood mixed with *Br. abortus* cells, only 5 percent of the neutrophiles showed ingestion of 2-5 bacteria. Ingestion of *Brucella* was not observed in other blood cells.

Examination of the blood of the rabbits 10 days after the second injection of the vaccine showed that the plasma was highly bactericidal for *Brucella*, and that three types of cells had high phagocytic activity. After a 3-day period of incubation of 100 brucella cells in a 1:7 dilution of the plasma in liquid culture medium, no living brucella cells were found on sub-culture.

Citrated whole blood was mixed with brucella cells (10^9 cells/ml. of blood) to determine change in the phagocytic activity of leucocytes. At the end of the first 30 minutes at 37° C., the cytoplasm of all neutrophiles, of all monocytes, and most of the thrombocytes examined in stained smears made on cover-glasses were filled with brucella cells. The thrombocytes, although small in diameter, contained from two to six bacteria. This observation was unusual as this type of cell has never been labeled as a phagocytic (bacteria) type.

Examination of the mixture after one hour of incubation showed many of the bacteria within the cytoplasm of the monocytes to be in

various stages of lysis. This change was not observed in bacteria in neutrophiles. At this time, specific agglutinins were not demonstrated in the serum of the rabbits.

Beta-propiolactone may also be used for the inactivation of S-type brucella cells in the preparation of antigens for the agglutination test. The final concentration should never exceed 0.15 percent for 10^{11} cells/ml. In higher concentrations of this agent, the bacteria become unstable and agglutinate. This physical change in the bacterial cells cannot be reversed by centrifuging and washing several times with physological salt solution.

SUMMARY

Brucella cells (10^{11}/ml.) of three colonial types were rapidly inactivated by beta-propiolactone in a final concentration of 0.1 to 0.15 percent.

Of four enzyme systems studied, only one was inactivated by beta-propiolactone when the concentration did not exceed 0.15 percent.

Cells of one mucoid type of *Br. suis* inactivated by beta-propiolactone produced a high degree of immunity in guinea pigs against infection with *Br. abortus,* provided two injections were given at intervals of 10 days.

The bactericidal action of blood plasma and phagocytic activity of blood cells (neutrophiles, monocytes, and thrombocytes) were markedly increased following two separate injections of cells of a mucoid colonial type of *Br. suis* that were inactivated by beta-propiolactone.

ACKNOWLEDGMENT

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FREEZING TOMATOES

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Every fall we have a number of requests for information on freezing tomatoes. Available directions advise against freezing tomatoes since they tend to collapse when thawed, becoming very flabby and soft. However, it seemed worthwhile to us to explore the possibilities of freezing tomatoes for certain uses.

PROCEDURE

Three varieties of tomatoes were used—Marglobe, Rutgers and Big Boy. Sizes ranged from 1¾ to 3¾ inches in diameter, with most of the smaller tomatoes being Rutgers or Marglobe. None of the Big Boy variety was less than 2½ inches in diameter.

The tomatoes were sorted for size and ripeness. Those still somewhat green were allowed to ripen at room temperature before being frozen. The different sizes were grouped for blanching, with the large tomatoes being blanched longer than the small ones.

The following procedure was used in preparing the tomatoes for frozen storage. Preliminary trials had indicated that this method was the most satisfactory of those checked.

1. Blanching: Immerse small tomatoes in boiling water for 1¼ minutes; large tomatoes for 1½ minutes.

2. Cooling: Cool in cold running water. Remove skin, cut out stem scar and any defects.

3. Wrapping: Wrap whole tomatoes individually in moisture-vapor-proof material.[2] Seal. Freeze immediately in single layer on bottom of freezer.

4. Storage: Freeze and store tomatoes at 0° F. Test after 1, 2½, 4 and 6 months storage.

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[2]Saran and aluminum foil used in experiments.

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5. Testing: The tomatoes were removed from the freezer and partially thawed at room temperature (2 to 2½ hours). Then each tomato was unwrapped, cut into sixths, and served at once. The tomatoes were scored by a panel of four judges. Points considered included general appearance, color, odor, flavor, texture, and general acceptability. A seven-point scale was used; 7 being excellent; 1 very poor. Three replications were done on each lot.

RESULTS (See Table 1)

VARIETY OF TOMATO

All three varieties gave about the same overall results. The Big Boy tomatoes seemed to be slightly better than Marglobe or Rutgers

TABLE 1—Average scores for frozen tomatoes

Variety	Wrap	Storage months	General appearance	Color	Odor	Flavor	Texture	General acceptability
Marglobe	Aluminum foil	1	4.7	4.4	4.2	4.3	4.6	4.1
		2½	4.9	5.0	4.6	4.1	4.1	4.2
		4	5.4	6.4	4.4	4.1	4.4	4.4
		6	5.0	6.3	5.0	3.9	4.1	4.0
	Saran	1	5.1	5.5	4.5	4.2	4.5	4.2
		2½	4.6	4.3	4.4	3.6	4.4	3.7
		4	4.4	5.5	4.1	3.3	4.0	3.4
		6	5.7	5.9	5.2	4.9	4.6	4.9
Rutgers	Aluminum foil	1	5.0	4.9	4.8	4.4	4.4	4.4
		2½	4.8	4.8	3.7	4.0	4.4	4.0
		4	5.3	5.0	5.0	3.4	4.7	3.8
		6	5.4	5.6	5.1	3.8	4.6	4.1
	Saran	1	4.7	5.2	4.7	3.8	4.1	3.9
		2½	5.1	5.1	4.0	3.9	4.2	4.0
		4	5.3	5.8	5.1	4.8	4.7	4.8
		6	5.5	6.1	5.4	4.6	4.5	4.5
Big Boy	Aluminum foil	1	5.4	5.3	4.4	4.4	4.6	4.7
		2½	4.8	4.7	4.2	4.4	4.4	4.3
		4	5.4	5.5	3.4	4.0	4.7	3.9
		6	5.2	5.1	5.0	4.4	4.5	4.2
	Saran	1	4.2	5.4	4.6	4.7	4.5	4.3
		2½	5.0	5.0	4.4	4.0	4.1	4.3
		4	4.6	5.5	3.9	4.6	4.8	4.4
		6	4.7	5.3	4.8	5.0	4.7	4.5

after 1 and 2½ months' storage, but this advantage, never very great, disappeared with longer storage.

WRAPPING

The results, except in isolated instances, were quite similar for the two types of wrapping material.

LENGTH OF STORAGE

None of the scores was high enough to indicate a really desirable product, even after only one month of frozen storage. However, there was no evidence of marked deterioration with length of storage. In some instances, the samples stored for longer periods had higher scores than those stored for shorter times.

RECOMMENDATION

Tomatoes may be frozen according to the directions given. However, frozen tomatoes are difficult to handle, and not very attractive. They leak badly as they thaw, so there is always a good deal of juice in the package when the tomato is unwrapped. After they are cut for serving, they continue to leak and collapse quite rapidly. In most cases, homemakers will find it more satisfactory to rely on canning rather than freezing for keeping tomatoes, plus cool storage of individually-wrapped green tomatoes in the fall to lengthen the season a month or two.

CONSUMPTION OF ROUGHAGE SELF-FED TO DAIRY COWS

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SELF-FEEDING ROUGHAGES to dairy cattle in loose-housing has focused attention upon the requirements for feed and feeder space needed for this system.

Some information is available regarding roughage consumption. Blosser and his co-workers (1952) obtained a daily consumption of 91.0 pounds of self-fed alfalfa-grass silage per cow when hay was limited to 5 pounds daily, and 100.6 pounds when no hay was provided. Porter (1953) self-fed various combinations of hay, corn silage, and grass silage to dry cows. When fed hay and grass silage, the cows ate an average of 15.0 and 41.7 pounds respectively. Thirteen pounds of hay and 57.0 pounds of corn silage were eaten when these roughages were offered. When corn and grass silage were both offered, the cows ate 50.0 and 23.0 pounds respectively. The cows each consumed a daily average of 7.6 pounds of hay, 33.0 pounds of corn silage and 19.0 pounds of grass silage when all three roughages were made available.

Additional observations have been made regarding the roughage consumption and eating habits of cows being self-fed hay and corn silage in the loose-housing research barn at Michigan State College.

MATERIALS AND METHODS

The data reported herein were obtained during the non-pasture seasons of 1952-53 and 1953-54. The observations were made on a herd of Brown Swiss cows during the first year, and a mixed Brown Swiss and Holstein herd during the second year. This herd was maintained in a steel, quonset-type, loose-housing barn. Hay was self-fed

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from a storage barn located along one side of the paved lot, while a vertical, self-feeding silo was located in the lot.

During the winter of 1952-53, the cows had free access to hay and corn silage from early November to January 10. Thereafter, hay was fed as their only roughage. A series of 24-hour observations of the activities of each animal in the herd were made during this period.

For the second year, the lot and lounge areas were divided and the herd split. One part of the herd was self-fed hay and corn silage, while the remainder had free access to hay as their only roughage. The observations of the previous year were repeated and, in addition, consumption of each roughage was determined.

Roughage consumption was measured on several occasions by closing the self-feeders and placing weighed amounts of hay and silage in racks or troughs for periods of 48-72 hours. Self-feeding conditions were simulated by stirring the weighed-out roughage, and by frequently adding fresh hay or silage. The reliability of this procedure was checked in the hay-silage group by weighing out one roughage while the other was self-fed, and comparing consumption with that obtained when both roughages were weighed.

RESULTS AND DISCUSSION

EATING HABITS

The eating habits observed during the 1952-53 feeding period have been discussed in a previous paper (Lewis and Johnson 1954). Further observations in 1953-54 indicated the same pattern.

TABLE 1—Frequency with which dairy cows ate when self-fed hay and corn silage or hay alone

	When self-fed roughage was		
	Hay and corn silage		Hay alone
	Hay	Silage	
Year	1952-53	1952-53	1952-53
Number of cow days	60	60	57
Ave. number of times ate			
6 a.m. to 6 p.m.	1.5	3.8	3.8
6 p.m. to 6 a.m.	1.2	2.7	1.5
Total daily	2.7	6.5	5.3
Range	0–6	1–11	1–9

Table 1 shows the frequency with which the cows ate under the two feeding conditions. The inclusion of silage in the ration appeared to encourage eating at frequent intervals. When they were given both hay and silage, the cows ate on an average of 9.2 times daily, while on hay alone they ate only 5.3 times a day.

Since the cows ate silage more than twice as often as they did hay when they had access to both, it seems clear that there was a preference for the former. On the other hand, there was little difference in the total time spent eating, regardless of the kind of roughage provided (Table 2). Probably most of the evident differences between the two years were due to the fact that in 1952-53, the silage was fed from a tightly compacted mass; while in 1953-54, changes in silo design permitted the silage to loosen as it slipped downward.

TABLE 2—Time spent eating roughage by dairy cows in loose-housing

	When self-fed roughage was					
	Hay and corn silage				Hay alone	
	Hay		Silage			
Year	1952-53	1953-54	1952-53	1953-54		
Number cow days	60	35	60	35	57	21
Average minutes eating						
6 a.m. to 6 p.m.	34	45	188	150	213	208
6 p.m. to 6 a.m.	48	22	77	72	90	119
Total daily	82	67	265	222	303	327
Range	0–290	—	30–460	—	30–540	—
Maximum	130	—	140	—	180	—

Since the cattle distributed their eating throughout the day and night, it was not necessary to provide as much feed-rack space per animal as is often recommended. In the college's system, approximately 20 inches of hay feeder and 15 inches of silo space were provided for each animal. These allowances were ample for the silo, and greater than necessary for hay feeding. Probably no more than 15 inches of feeder space need to be provided for either method when continuous access to the roughage is permitted.

ROUGHAGE CONSUMPTION

The data presented in Table 3 show that the cows in this herd ate an average of 58.6 pounds of corn silage and 7.1 pounds of day daily

TABLE 3—Roughage consumption by cows in loose-housing

Trial	Number of days	When self-fed roughage was		
		Hay and silage		Hay alone
		Hay	Silage	
1.....	3	7.0*	53.3*	16.9*
2.....	2	6.2	58.2	19.8
3.....	2	7.7	56.8	22.7
4.....	3	—	60.2	—
5.....	2	7.2	—	23.0
6.....	2	7.3	—	—
Average.....		7.1	58.6	22.0

*Not included in average of all trials.

when both roughages were available. When fed hay alone, they ate about 22 pounds per cow daily.

The first trial was not included in the average of all trials because the roughages for the entire 3-day period were placed in bunks at the start of the experiment. Since the cattle did not receive any fresh feed, the conditions did not approximate those of self-feeding. In subsequent trials, fresh feed was placed before the cows three times daily.

As the table shows, the cows ate about eight times as much silage as hay on a weight basis. The dry matter intake was higher when hay and silage were fed than when hay formed the only roughage. By applying Morrison's digestion coefficients to the composition of the hay and silage and assuming 1,400 pound cows, it was estimated that the group on hay alone received 105 percent of their maintenance requirements, while the hay-silage group obtained 151.8 percent. Thus, under the prevailing feeding conditions, the use of silage aided materially in increasing the nutrient intake from roughage.

An attempt was made to determine the effect of including corn silage in the ration on the necessary concentrate feeding rate, but, due to the small number of animals on which comparisons could be based, the results were inconclusive.

MILK FLAVOR

It is well known that feeding shortly before milking may cause off-flavors to occur in the milk. On three occasions, samples of morning and evening milk from each cow in the herd were evaluated for

flavor defects. An average of 79 percent of the samples taken in the evening and 21 percent of those taken in the morning had a feedy flavor. These results undoubtedly reflect the fact that, prior to the evening milking, most cows spent some time eating, while few animals ate during the last several hours before the morning milking.

The feed flavors noted did not seriously affect the quality of the milk in this case. However, under some conditions, these off-flavors might be a cause of concern. The only solution appears to be to close off the feeder space for a few hours before milking in those cases where serious off-flavors appear.

SUMMARY

The roughage eating habits of a herd of cows self-fed in a loose-housing system have been studied during the non-pasture season for two years. When fed hay and corn silage, the cows ate silage on an average of 6.5 times and hay 2.7 times daily. They consumed an average of 7.0 pounds of hay and 58.6 pounds of silage. Cows receiving hay alone ate an average of 22.0 pounds daily in 5.3 trips to the feed-rack. Although the cows fed hay alone ate fewer times, they spent approximately the same average number of minutes daily eating as did the animals receiving both hay and silage.

Flavor tests on the milk produced showed that feed flavors occurred in 79 per cent of the evening and 21 percent of the morning samples. This probably was related to the eating habits of the cattle.

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WHEN TO BREED AFTER CALVING

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"WAIT 60 DAYS after calving before breeding your cows," has been quite universal among dairy specialist recommendations to dairymen, and most all scientific research on the subject has upheld the recommendation. Researchers in New York[1] showed that for a good reproductive performance, the first service should be over 50 days after calving for normal dairy cows in good genital health. Results from Illinois[2] also indicated that a minimum of 50 days from calving to first service was required for satisfactory fertility.

The purpose of this study was to gather like information from a sufficient number of Michigan dairy cows, and to learn if there was a difference between breeds. The data for this study were obtained from 20 inseminators for the Michigan Artificial Breeders Cooperative, representing different areas of the state.

RESULTS AND DISCUSSION

Data was obtained for 5,317 cows, including 3,661 Holsteins, 1,116 Guernseys, 275 Jerseys, and 265 others and mixed breeds. The number of days fresh to first service and for all repeat services were calculated on each cow. Cows that had over four services were excluded from the study. Cows that did not have a repeat service after 90 days from time of service, were assumed conceived.

The length of time after calving that the cows were serviced artificially is shown in Table 1. The data may be a reliable indication of when all cows in Michigan are bred artificially after calving.

[1]Trimberger, George W. (1954). Conception rates in dairy cattle from services at various intervals after parturition. Jour. Dairy Sci. 37: 1042-1049.

[2]Shannon, F. P., G. W. Salisbury, and N. L. VanDemark (1952). The fertility of cows inseminated at various intervals after calving. Jour. Animal Sci., 11: 355-360.

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TABLE 1—Percent of total cows bred at various time intervals after freshening.

Days fresh at first service	Number of cows	Percent of total
39 less	239	4.4
40–49	335	6.3
50–59	508	9.6
60–69	996	18.7
70–79	876	16.5
80–89	653	12.3
90–99	715	13.4
100–119	432	8.1
120 over	563	10.6

Over 20 percent of the cows were bred less than 60 days after calving. No differences were found between breeds of cows as to how soon after calving they were bred.

The percent of the cows that conceived on first service and the average number of days to conception for repeat service cows, is given for each group in Table 2 (days fresh at first service).

TABLE 2—Percent non-returns at various time intervals.

Days fresh at first service	Number of cows	Percent of cows conceived on first service	Average number of days to conception for repeat service cows
39 less	239	49.2	84
40–49	335	57.0	91
50–59	508	62.8	105
60–69	996	59.9	114
70–79	876	63.1	125
80–89	653	63.1	141
90–99	715	62.8	147
100–119	432	63.9	162
120 over	563	66.4	200
Totals or average	5,317	61.9	131

Data in Table 2 reveal that the percent of cows conceiving on first service does not level off until the 50–59 (days fresh at first service) group. The conception rate of the first two groups was significantly

lower than the other groups. The results of this study agree substantially with that of others. *Favorable conception results are not reached until dairy cows have been fresh at least 50 days.*

Cows that did not conceive on first service took an average of 50 days for conception. It took slightly longer for repeat cows in the first two groups. No significant differences between breeds could be found on conception rate for the postpartum groups.

Improvement in conception rate closely follows the return of the cow's reproductive tract to normal after calving. The organs are in poor condition to support the developing foetus sooner than 50 days following parturition.

Dairymen who wish to change the freshening time of their cows to meet the "base" period should be well aware of the risks involved in breeding cows too soon after calving. If a cow has calving trouble, retained placenta, or a diseased reproductive tract, it would be wise to hold off breeding and consult your veterinarian.

In actual practice, if a cow will conceive on the first service, the dairyman can wait from 70 to 80 days after calving before breeding. In this way, the cow can be milked for 10 months, with two months dry, and calve about every 365 days.

SUMMARY

Information on 5,317 cows regarding the number of days fresh at first service was obtained from 20 local affiliates of the Michigan Artificial Breeders Cooperative. The percent of non-return rates obtained indicated that better conception in dairy cows will result if they are not bred sooner than 50 days after calving. Cows that did not conceive on first service took an additional 50 days, on the average, to conceive.

No breed differences were noted on conception rates at various intervals of breeding after calving. Twenty percent of the cows were bred less than 60 days after calving with 56.3 percent non-return; while 47.5 percent of the cows were bred between 60 and 90 days after calving with 62 percent non-return rate.

DRY DIETS FOR RANCH-RAISED MINK

I. Suitability for Late Growth and Maintenance

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Fur Animal Nutrition Project.

Department of Poultry Husbandry and the Institute of Nutrition

Practical mink rations have always contained large amounts of fresh or frozen horsemeat, fish, and packing plant by-products. In recent years, horsemeat has become increasingly scarce and expensive. The use of fish and packing plant by-product combinations offers a satisfactory substitute but, as with horsemeat, expensive refrigeration and mixing facilities are required. The successful feeding of other animals with rations composed of readily available, easily stored dry ingredients has led to attempts to develop a successful, all-purpose, dry ration for mink.

Prior work by Travis *et al.*[1] and Howell,[2] resulted in the formulation of a dry diet for ranch-raised mink which allowed sub-optimal growth, maintenance, and reproduction.[3]

In 1953, based on the results of small-scale feeding trials conducted the previous winter, an experiment was conducted to compare the ranch-type "wet" ration in Table 1 with the "dry" diets (about 7% moisture) in Table 2. This report summarizes the results obtained on the maintenance of adult mink.

The period studied extends from the end of August when the kits were about 16 weeks of age until early March, the beginning of the breeding season. A subsequent report will discuss the results obtained during the breeding and whelping season and during the period of early growth of mink kits.

[1]Travis, H. F. *et al.* (1949). Mink feeding experiments: Report I. Mich. Agr. Exp. Sta. Quart. Bul. 32: 1, 64-69.

[2]Howell, R. E. (1952). A nutritional study of ranch raised mink. Thesis for degree of M.S., Mich. State Col., East Lansing.

[3]——— (1951). Unpublished data.

ARTICLE 37-71

PROCEDURE

Four groups, each consisting of twenty dark mink, were used. Each group consisted of five adult males, three kit males, five adult females, and seven kit females. Approximately half of the mink in each group were raised at the M.S.C. mink project, and half were added from an outside source about 3 weeks prior to the beginning of the experiment. All animals were individually confined out-of-doors in wire mesh cages with nest boxes.

Those animals on the control "wet" ration were fed daily. The experimental "dry" rations were mixed at the college and pelleted at a commercial feed mill. A supply of the pellets was kept available in each animal's cage by filling the feed container when necessary. Water was constantly available except during the extremely cold part of the winter when freezing forced the animals to consume ice. All animals were weighed at weekly intervals, weather permitting.

The data reported is broken down into two successive periods. The first, from August 30, 1953 until December 14, 1953, covers the period of late growth and maintenance until pelting time. The second, from December 15, 1953 until March 6, 1954, covers the maintenance of breeding animals until the beginning of the breeding season.

Prior to the start of this feeding trial, the animals (with the exception of the control group) were fed dry diets supplemented by a daily feeding of the control ration. This period of supplementary feeding varied in length from 3 to 6 weeks, depending on the source of the animals.

The control ration used (Table 1) contained horsemeat, liver, fish, tripe, and a supplemented cereal. The experimental dry rations (Table 2) were identical, except that rations A and B contained 15 percent dried yeast, and ration C contained 15 percent additional soybean oil

TABLE 1—Constitutents of control diet

Ingredients	Percentage
Horsemeat and bone	50
Fish, ocean	15
Tripe	15
Liver	5
Cooked cereal*	15

*Kellogg's Mink Ration—no meat 1001.

TABLE 2—Constitutents of experimental diets

Ingredients	A	B	C
	Percent	Percent	Percent
Cooked cereal mix (corn, wheat, rice)*	36	36	36
Dried yeast, torula	15	—	—
Dried yeast, brewers	—	15	—
Soybean oil meal (50% protein)	10	10	25
Fish meal (55% protein)†	10	10	10
Herring meal (70% protein)	5	5	5
Meat scraps (65% protein)	5	5	5
Livermeal‡	5	5	5
Fish glandular hydrolysate§	5	5	5
Fish solubles§	1	1	1
Tomato pomace	2	2	2
Skim milk, dried	2	2	2
Dried soluble blood	2	2	2
Choline chloride (25%)	0.8	0.8	0.8
Vitamin mix‖	0.2	0.2	0.2
Terramycin T M-5	0.2	0.2	0.2
	Per 100 lbs.	Per 100 lbs.	Per 100 lbs.
Vitamin A (10,000 U.S.P. units/gm)	51 gm	51 gm	51 gm
Vitamin D (3,000 I.C. units/gm)	45 gm	45 gm	45 gm
Vitamin E (20,000 I.U./lb.)	20 gm	20 gm	20 gm
$MnSO_4$ (feeding grade)	10 gm	10 gm	10 gm
Folic Acid (3%)	5 gm	5 gm	5 gm
Vitamin B_{12}	2.5 mg	2.5 mg	2.5 mg

*Cereal Mix 1007, Kellogg Company, Battle Creek, Mich.
†Vitaproil 75-A, Maine Marine Products, Inc., Portland, Me.
‡Ritaliver, Imperial Products Co., Wadsworth, Ill.
§Philip R. Park Co., San Pedro, Calif.
‖Fortafeed 2-49C, Lederle Laboratories, Pearl River, N. Y.

TABLE 3—Proximate analysis of the rations fed, 1953-54

Ration	Moisture	Crude Protein	Crude Fat	Crude Fiber	N.F.E.	Ash	Ca	P
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Control "wet"	70.74	15.14	4.42	0.58	7.35	1.77	0.85	0.55
Control "air-dry basis"	7.00	48.11	14.05	1.84	23.36	5.63	2.70	1.75
A	6.88	37.50	5.86	2.51	39.00	8.25	1.08	1.10
B	7.14	36.56	5.24	2.16	41.45	7.45	1.02	1.13
C	6.96	38.88	5.18	2.41	39.03	7.54	1.10	1.04

Analysis made by Dr. E. J. Benne, Department of Agricultural Chemistry, Mich. State College.

meal which entirely replaced the dried yeast. This kept the crude protein content of the experimental rations similar.

Previous trials had shown no apparent unpalatability resulting from the high levels of yeast and soybean oil meal. This was borne out during the period of this experiment; all dry diets were consumed at an equal rate, indicating that they were equally palatable.

The proximate analysis of the rations fed is included in Table 3. The three dry diets were approximately equal in composition. The analysis of the control "wet" ration is shown "as is", and also calculated to an air-dry (7 percent moisture) basis. This allows a direct comparison with the dry rations. All nutrients were supplied in excess of National Research Council recommendations.[4]

RESULTS

The results of the experiment are summarized in Table 4. During the first period (August 30 to December 15), all animals gained weight. However, the gains by the mink on the dry diets were less than those made by the mink on the control ration.

[4]Committee on Animal Nutrition (1953). Nutrient Requirements for Domestic Animals, VII, Nutrient Requirements for Foxes and Mink. Washington, D. C.

TABLE 4—Late growth and maintenance results: Aug. 30, 1953-March 6, 1954*

	Control ration		Ration A		Ration B		Ration C	
	Males	Females	Males	Females	Males	Females	Males	Females
PERIOD AUGUST 30, 1953 TO DECEMBER 14, 1953								
At start								
Number of mink	8	12	7	12	8	12	8	12
Average weight	1196	689	1061	582	1160	622	1003	641
Range in weight	960–1440	520–770	895–1175	485–755	900–1400	550–760	670–1470	480–800
At finish								
Average weight	1516	888	1140	666	1280	718	1179	721
Range in weight	1060–1760	740–1100	930–1340	580–760	1020–1590	610–880	790–1530	460–920
Average gain	+320	+199	+79	+74	+120	+96	+176	+80
Number pelted	2	1	2	2	2	2	2	2
Mortality	0	0	0	2	0	0	0	0
PERIOD DECEMBER 15, 1953 TO MARCH 6, 1954								
At start								
Number of mink	6	11	5	8	6	10	6	10
Average weight	1485	893	1068	651	1330	728	1133	718
Range in weight	1060–1760	740–1100	930–1150	580–750	1090–1590	650–880	790–1280	460–920
At finish								
Average weight	1562	846	1040	643	1303	694	1115	686
Range in weight	1050–1960	700–1070	970–1080	560–780	950–1650	620–850	770–1290	510–880
Average gain	+77	−47	−28	−8	−27	−34	−18	−32
Mortality	0	0	0	1	0	0	2	0

*All weights are in grams.

Analysis of variance, comparing each of the dry diet groups with the control group, showed that all gains were significantly less (at the 5 percent level of probability). A similar comparison showed all dry diets to be statistically equivalent; i.e., the slight weight variations shown in Table 4 are due to chance.

At the end of this period, as a normal culling measure the four poorest mink (two males and two females) were removed from each of the dry ration groups and pelted. Two males and one female were removed from the control group. The carcasses were opened and a gross examination of the internal organs was made. No gross differences were observed. Since the animals were not chosen for pelt quality, the pelts were not graded for fur quality.

The two females that died during this first period were both on ration A. Gross examination showed that neither death could be attributed to the lack of any nutrient other than water.

In the second period (December 15 to March 6), all animals maintained weight satisfactorily on their respective diets. The slight gains and losses shown by the various groups are considered to be normal fluctuations. In actual practice on commercial ranches, the animals on the control ration would have been fed so as to lose 100-200 grams during this period, because experience has shown that thinner animals breed more satisfactorily.

DISCUSSION AND SUMMARY

Although the dry diets used in this experiment did not allow as large gains as the control ration during late growth, the diets appeared to be adequate in all other ways. It is felt that all of these dry diets were satisfactory for maintenance. The weight differences between the control and experimental groups were more the result of fattening than of any other factor.

Table 3 shows that the control ration contains more protein and fat than any of the dry diets. Fattening is not necessary for maintenance of replacement stock. In practice, mink ranchers fatten all the mink in their herd each fall until pelting time; then, after the first of the year, they try to thin the breeding stock down so that they will breed and reproduce satisfactorily.

This experiment shows that the animals could be maintained satis-

factorily on a dry diet once the breeding stock is selected until breeding season, with a saving in both feed and labor costs.

Perhaps one of the major problems encountered was that of supplying adequate water to the mink on the dry diets. Because the dry diets contained only 7 percent moisture, these animals in freezing weather were under much more severe strain than those on the control diet which supplied approximately 70 percent moisture in the feed.

During prolonged cold spells, the food intake of the animals on the dry diets was markedly depressed, with a resultant weight loss. We believe that the three deaths which occurred during the second period, as well as the two in the preceding period, may be attributed directly to this lowered water intake.

From the results of this study the following tentative conclusions seem justified:

Palatability of dry rations does not appear to be a factor. The mink ate all rations readily if adequate water was available. No instances of feed refusal were noted.

Soybean oil meal, even at the highest level fed, showed no evidence of unpalatability and the protein content apparently was as available to the mink as it was in the two types of yeast fed.

No differences were noted between the two types of yeast (torula dried yeast and brewers' dried yeast). Both appeared to be equally palatable, even at the 15 percent level, and the protein therein equally available.

The present rations seem to be needlessly complex. We feel that all essential nutrients are present in excess, perhaps to the detriment of the ration. Attempts at simplification are now being made and will be reported upon at a later date.

One of the major problems in the formulation of a satisfactory dry diet seems to be that of digestibility. The mink has an extremely short digestive tract and, for best results, a dry diet should be composed of high quality, readily-digestible ingredients.

The availability of water is a limiting factor in the use of dry diets in freezing climates. Successful use of dry diets in winter will require some sort of a water system which will keep water from freezing. Experimental work along this phase is now being conducted here.

These experiments are being continued through another year to determine the effects of long continued use of dry diets.

ACKNOWLEDGMENTS

We wish to express our gratitude to the following organizations: Michigan Fur Breeders Association; Sulphite Pulp Manufacturer's Research League, Inc.; Brewers Yeast Council, Inc. for their financial aid; W. K. Kellogg Company, Battle Creek, Michigan for donations of both mink and cereal; Imperial Products Co., Wadsworth, Illinois; Philip R. Park Co., San Pedro, California; Chas. Pfizer and Co., Inc., Brooklyn, N. Y.; A. E. Staley Manufacturing Co., Decatur, Illinois, for donations of feed ingredients.

JOURNAL ARTICLE ABSTRACTS

Recent Studies on the Mechanisms Controlling the Initiation of Lactation

MEITES, J.

Revue Canadienne de Biologie 13:359-370. 1954. (Journal Article 1576 from the Michigan Agricultural Experiment Station)

(1) Lactation is believed to be held in check during pregnancy by two mechanisms, each of equal importance. First, the combined action of estrogen and progesterone stimulates growth of the mammary gland but makes it refractory to prolactin stimulation. Second, the secretion rate of prolactin during pregnancy, as in the pre-pregnant state, is too low to initiate abundant lactation. This is not believed to be due to any inhibition of prolactin secretion by the ovarian hormones, although **stimulation** of the pituitary by estrogen may be prevented by progesterone.

(2) Lactation can continue in animals which subsequently become pregnant, because the initial level of prolactin secretion is already high and remains high as the result of the nursing stimulus and removal of milk. The fact that the mammary gland is already actively secreting may also make it more refractory to growth stimulation by the two ovarian hormones.

(3) Prolactin secretion greatly increases about the time of or soon after parturition, and at the same time the mammary tissue becomes more receptive to prolactin stimulation. These serve to initiate copious milk flow.

(4) Estrogen may provide the stimulus for increased prolactin synthesis at parturition, but this may also come from the mammary gland itself. Suckling is not essential for the initiation of lactation, although maximum prolactin and milk production are not obtained without it.

The Reporting Period For A Consumer Purchase Panel

SHAFFER, J. D.

Marketing XIX:252-257. 1955. (Journal Article 1586 from the Michigan Agricultural Experiment Station)

The consumer purchase panel, like all survey techniques, is beset with numerous problems of methodology at the practical operating level. Determining the proper reporting period is one of these important practical problems. Three phases of this problem were investigated: (1) How long should the reporting period be? (2) On what days should the reporting period begin and end? (3) Should reporting be continuous or discontinuous?

Evidence was obtained which indicated that weekly reporting of grocery items has resulted in substantially more complete reports than monthly reporting. One study showed one-fifth more items were reported using weekly reports than monthly. A weekly reporting period starting on Sunday is most likely to result in complete reporting. Present evidence is strongly in favor of continuous reporting where reporting continuity of individual panel members and completeness of reports are important.

Some Nematodes of Rats From Guam, M. I. and Notes on a Species of Rictularia

LINDQUIST, W. D., AND S. Y. LI

Parasitology 41:194-197. 1955. (Journal Article 1595 from the Michigan Agricultural Experiment Station)

A list of nematode parasites found in rats from Guam in the Marianas Islands is presented. One species of the genus *Rictularia* is dealt with in particular since the male of this worm does not conform in morphology to *Rictularia tani* described from rats in China. Interestingly enough, the Guam females compare favorably with *Rictularia tani*. There does not appear to be enough evidence to establish a new species nor enough similarity in males to designate these worms from Guam as *Rictularia tani*. Before speciation can be secure, more material, particularly males, from the Orient and Marianas Islands should be compared.

Effects of Altering the Balance Between Prolactin and Ovarian Hormones on Initiation of Lactation in Rabbits

MEITES, J., AND J. T. SCOURIS

Endocrinology 55:530-534. 1954. (Journal Article 1624 from the Michigan Agricultural Experiment Station)

Thirty-six young rabbits were ovariectomized, and after 10 to 14 days were injected daily with 0.96 mg. of estrone and 1 mg. of progesterone for 24 days to induce optimal mammary development. From the 26th to 35th days, three groups of 6 rabbits each were continued on the same doses of steroid hormones together with 2, 4 and 8 mg. of prolactin daily, respectively; three other groups of 6 each were injected with 2 mg. of prolactin daily together with 0, ¼ or ½ of the 2 steroid hormones used previously. On the 36th day, the rabbits were killed and their mammary glands were exposed and rated visually for lactational response.

In the first 3 groups, lactation was almost completely inhibited when only 2 mg. of prolactin was injected daily in the presence of the two steroid hormones; 4 or 8 mg. daily elicited good lactational responses. In the second three groups, the greatest amount of milk was secreted when 2 mg. of prolactin was given daily without the steroid hormones, while the same dose of prolactin in the presence of either ¼ of ½ of the steroid hormones produced a smaller flow of milk.

It is concluded that the antagonism between mammary growth and lactation is relative, depending on the balance between the levels of prolactin and the two ovarian hormones in the body. When the mammary growth stimulus exerted by the two ovarian hormones is greater than the lactational stimulus of prolactin, milk flow will be inhibited, and **vice versa.** The application of these findings to explain the absence of lactation during a non-lactational pregnancy or the simultaneous coexistence of lactation and pregnancy is discussed.

Further Investigations on the Use of Maleic Hydrazide as a Sprout Inhibitor for Potatoes

RAO, S. N., AND S. H. WITTWER

Amer. Potato Jrnl. 32:51-59. 1955. (Journal Article 1654 from the Michigan Agricultural Experiment Station)

During two years of study, the effectiveness of preharvest foliar sprays of maleic hydrazide (MH) in retardation of storage sprouting in potatoes without accompanying yield reductions and deformed tubers is dependent upon time of application with respect to the stage of plant development and influenced greatly by variety. In 1952-53, a postbloom application (August 4) very effectively controlled sprouting in Irish Cobbler, Triumph, Chippewa and Sebago with a reduction in total but not marketable yield.

Ten potato varieties in 1953-54 were planted May 15 and sprayed following plant emergence with MH at approximately two week intervals. With all varieties, the two earliest applications (June 15 and 29) resulted in significant reductions in yield accompanied by a high percentage of deformed tubers, a significant reduction in tuber size, and no practical reduction in storage sprouting. Application of MH on July 31 effectively controlled sprouting without yield reductions on Pontiac, Chippewa, Irish Cobbler and Katahdin, while the August 13 application was found most satisfactory for Russet Rural, Triumph, Russet Burbank, and Sebago.

It was concluded that MH may be successfully used as a preharvest spray for the retardation of storage sprouting in potatoes if applied to the green foliage 1 to 2 weeks after bloom and approximately 6 weeks prior to the anticipated harvest. Thus, May plantings harvested in late September might appropriately be treated August 10 to 15.

The Value of Corn Silage and Recombined Corn Silage in Respect to Milk Production

DUNN, K. M.; R. E. ELY; C. F. HUFFMAN AND C. W. DUNCAN

Jrnl. Dairy Sci. 38:58-64. 1955. (Journal Article 1659 from the Michigan Agricultural Experiment Station)

Alternate strips of green corn were placed in the silo. The remaining strips were used for grainless corn silage (ears removed) and ears (dried) for corn and cob meal. Corn silage and recombined corn silage were compared, using 13 cows in 14 trials. Recombined corn silage is construed to mean that a proportionate amount of the corn and cob meal was added to the grainless corn silage at the time of feeding.

The amounts of grainless corn silage and corn and cob meal to use was determined by collecting random samples of the green corn plant from the fields just prior to ensiling. The average amounts of 4 percent fat-corrected milk produced, the body weights, and the amount of digestible protein ingested during the corn silage and recombined corn silage periods were approximately the same in both cases. The data indicate that the corn grain in corn silage was of the same value for milk production as corn grain fed in the form of dry corn and cob meal.

Nitrate Reduction by Certain Strains of Lactobacillus plantarum

COSTILOW, R. N., AND T. W. HUMPHREYS

Science 121:168. 1955. (Journal Article 1672 from the Michigan Agricultural Experiment Station)

Eighteen of 38 strains of *Lactobacillus plantarum* were found to reduce nitrate to nitrite when grown in indole-nitrite medium (BBL). Representative strains failed to reduce nitrates when grown in nitrate broth (Difco). However, when 0.1 percent agar was added to nitrate broth these same strains reduced nitrate. Therefore, it is believed that this property of *L. plantarum* is dependent on the oxygen tension of the medium.

It is suggested that the descriptions of the family *Lactobacteriaceae* and of the genus *Lactobacillus* given in *Bergey's Manual of Determinative Bacteriology* be changed so as to permit the inclusion of those strains which reduce nitrates. Also, since this species has both nitrate positive and nitrate negative strains, consideration should be given to making a separate species of the nitrate positive strains.

Urea as a Protein Extender for Lactating Cows

WARD, G. M.; C. F. HUFFMAN AND C. W. DUNCAN

Jrnl. Dairy Sci. 38:298-302. 1955. (Journal Article 1676 from the Michigan Agricultural Experiment Station)

An experiment was conducted with 10 cows over a period of 12 weeks in which each of four treatments was tested by the Latin square design to determine the amount of milk produced by a urea and corn supplement compared to soybean oil meal. In all cases a low-protein roughage was fed, but the supplement was fed either by intimately mixing in the roughage or by placing it on top of the roughage.

No benefit was derived from mixing the supplement in the roughage because the cows promptly separated and consumed the supplement before eating the roughage. One cow consistently refused to eat the experimental ration containing urea.

The maintenance of body weight and the lack of significant difference in milk production as the result of treatment indicated that urea and soybean oil meal were of comparable value under the conditions of this experiment.

Engineering Considerations in a Controlled-Atmosphere Storage

PFLUG, I. J., AND D. H. DEWEY

Ag. Engr. 35:171-172. 1955. (Journal Article 1715 from the Michigan Agricultural Experiment Station)

Air leakage in the controlled-atmosphere apple storage as affected by pressure differences arising from changes in atmospheric pressure, air movement, temperature changes in the storage and the absorption or removal of gas from the storage, is discussed in relation to the design of the storage. Data are presented illustrating the effect of different volumes of atmosphere per bushel of McIntosh

apples on the time required for a heremetic storage to reach the desired oxygen level at 380°F. A room having 1.5 ft^3 of atmosphere per bushel of fruit requires about 9 days to reach an oxygen level of 3 percent while a room having 4 ft.^{3} of atmosphere per bushel required over 24 days.

Progress Report—Use of Vegetable Milk Replacements in Calf Nutrition

NOLLER, C. H., AND C. F. HUFFMAN

Proc. 10th Distillers Feed Conf. of Distillers Feed Research Council: 26-32. 1955. (Journal Article 1725 from the Michigan Agricultural Experiment Station)

Twenty-one 4-day Holstein calves were divided at random between three groups that were fed milk replacement formulas as follows: The calves of group one were fed the basal all vegetable formula; group two, the basal plus 5 percent dried whey; and group three, the basal plus 3.5 percent lactose. The experiment terminated when the calves were 60 days of age. The total amount of milk consumed was 50 to 55 lb. per calf.

The data showed no significant differences in average daily gain and feed efficiency between the calves on the three milk replacement formulas. However, calves on the formula containing dried whey were superior in appearance and had more costive feces. In this investigation, the critical period varied from 20 to 30 days of life. (Period of very slow growth.) After the critical period, the growth rate of the experimental calves was equal to that of the U.S.D.A. growth standard.

RECENT PUBLICATIONS
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SPECIAL BULLETINS

S-389 **On-the-Farm Refrigerated Fruit Storages** (28 pp., 8 figs., 6 tables)—For maximum benefits, on-the-farm refrigerated storages should be properly located, carefully planned and well managed.

S-390 **High Quality Roughage Reduces Dairy Costs** (28 pp., 12 figs., 6 tables)—The feed cost for producing 100 pounds of milk can be reduced 20 to 25 percent by improving the quality of the roughage and by feeding more roughage and less protein and grain.

S-391 **Economics of Grassland Farming** (31 pp., 6 figs., 16 tables)—This publication deals with the changes in farming operations resulting from a change in the grass program on an individual farm.

S-392 **Hay Harvesting Methods and Costs** (35 pp., 11 figs., 14 tables)—In deciding what haying method to use, consider the kind and quality of hay to be harvested and how well the method fits in with the farm organization.

S-393 **Marketing Christmas Trees in Michigan** (38 pp., 13 figs., 10 tables)—The value of the 1952 Michigan Christmas tree crop was about $2,700,000.

S-394 **Soil Conservation in Michigan**—Progress and Problems (36 pp., 6 figs., 24 tables)—District planners point out a need for balance in all phases of the program.

S-395 **How Michigan Inheritance Laws Affect Farm Ownership and Operation** (35 pp.)—A study of the settlement of farm estates in a selected Michigan township over a 26-year period.

S-396 **Prepackaging Apples in Film Bags** (19 pp., 8 figs., 4 tables)—The convenience of the film bag method and its visual appeal make it ideal for self-service merchandising.

S-397 **Milk Producers Entering and Leaving the Detroit Market** (44 pp., 14 figs., 10 tables)—This recent study indicates that producers entering and leaving the market are strongly influenced by price relationships and other economic factors and that with adequate price incentives, the Detroit market can gain new producers rapidly.

S-398 **Long Range Financial Planning by Local Farmers Cooperatives** (24 pp., 7 figs., 8 tables)—The replacement problem facing an association at the present will depend in large part on how well it has been able to adjust to the effects of inflation during the war and postwar years.

TECHNICAL BULLETINS (Not Intended for Popular Reading)

T-240 **A Comparison of Home Management in Two Socio Economic Groups** (50 pp., 5 figs., 24 tables)—A study of 52 homemakers in two different socio-economic groups living in Battle Creek and Lakeview, Michigan.

T-241 **Michigan Potato Producers and Price Support Programs** (39 pp., 2 figs., 28 tables)—Discussion of price support programs, production controls and the federal marketing order.

T-242 **Factors Influencing Height Growth of Planted Yellow-Poplar in Southwestern Michigan** (44 pp., 18 figs., 8 tables)—Height and radial growth appear to be more closely related to growing season precipitation and soil moisture than with variations in temperature.

T-243 **Effect of Sods, Mulches and Fertilizers in a Cherry Orchard on Production, Soluble Solids and on Leaf and Soil Analyses** (39 pp., 14 figs.)—The highest yield was obtained with the combination of clean cultivation with a mulch of straw or alfalfa.

T-244 **Weights of Foods Eaten per Meal by 242 Women 30 to 92 Years of Age** (32 pp., 7 figs., 14 tables)—Most of the subjects showed wide variation in the weights of the same foods selected at different meals, with subjects in the advanced age groups tending to eat smaller amounts of food than did the younger women.

T-245 **Harvest Maturity and Ripening of Peaches in Relation to Quality of the Canned and Frozen Products** (31 pp., 7 figs., 21 tables)—In general, the best flavor in both canned and frozen samples was obtained with fruit requiring 3 to 7 days to ripen fully.

T-246 **Clothing Inventories and Preferences Among Rural and Urban Families** (46 pp., 3 figs., 24 tables)—One of the outstanding findings of the study is the importance of metropolitan influences as opposed to local community influences upon clothing behavior and attitudes.

T-248 **Consumer Purchases of Butter and Oleomargarine** (32 pp., 4 figs., 9 tables)—The first in a series of bulletins based upon data obtained through the Michigan State College Consumer Panel. Factors influencing purchases of butter and oleomargarine are analyzed.

T-249 **Factors Affecting Purchases of Ice Cream for Home Use** (28 pp., 7 figs., 8 tables)—Over the 104 weeks of the study, the percentage of families purchasing varied more with temperature changes than did quantity of purchase.

T-250 **The Effects of the Price Support Program on the Dry Bean Industry in Michigan** (70 pp., 17 figs., 7 tables)—An analysis measuring the effects of factors influencing planted acreage, yield and price of dry beans under postwar price supports.

Upon request one copy each of these publications will be sent free to Michigan residents, to libaries, and to individuals engaged in educational work outside of Michigan.

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